

Cornwall Local Energy Market – Householder Survey Report

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The Householder Survey included an online survey which was emailed to all participants, and interviews held with 42 householders. This report outlines the results of the Householder Survey and is scoped around three research objectives.

Keywords: LEM, householders, motivations, environment, trading, innovation, networks, local, renewables

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Disclaimer

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Summary

In 2019 the University of Exeter undertook a survey with the 100 householders who participated in the domestic trial component of the Cornwall Local Energy Market (LEM) project.

The Householder Survey included an online survey which was emailed to all participants, and interviews held with 42 householders. This report outlines the results of the Householder Survey and is scoped around the following three research objectives:

Objective 1: Evaluate householders' experience of the LEM so far.

Objective 2: Identify characteristics that might define who is likely to or unlikely to engage in the provision of flexibility, energy or other services via a local energy market.

Objective 3: What might encourage people to participate? What needs to change to incentivise participation?

Key Findings

Overall, the householders were thankful for their free equipment and for the opportunity to take part in the trial. They valued their contribution towards research and hoped that by being involved in the trial that they could help to prove that the viability of the LEM concept. They also valued the opportunity to test the equipment installed as part of the project and to assess the impact this had on their household by way of behaviour change and electricity demand.

We identified 5 motivational factors for the householders engaging in the LEM trial. These factors were not mutually exclusive, with people generally identifying with at least 2 of them:

- Financially motivated
- Environmentally motivated
- Community motivated
- Innovation / research motivated
- Technology motivated

Although the financial motivation was cross-cutting against all of the other 4 motivations it was rarely the single motivator; with the 4 more qualitative motivations being of equal or higher importance to many of the householders.

The householders could see the environmental benefits of a LEM model in addressing grid flexibility needs and saw this as a solution to enabling more renewable generation to connect to the distribution network. However, there were different opinions in how this could best be achieved.

Whilst the LEM concept was considered to be a useful option to realising the UK's net-zero ambitions by 2050, it was considered that there needed to be much more communication with the wider public on what the future energy system might look like in response to addressing climate change. In addition, it was considered that greater government intervention was needed to enable and finance householders to partake in energy system change at the domestic level.

Introduction

The Cornwall Local Energy Market (LEM) project is a three-year trial from 2017 to 2020 jointly funded through the European Regional Development Fund and Centrica. The project is led by Centrica in association with project partners Western Power Distribution (WPD), National Grid, Imperial College London and the University of Exeter (UoE).

The LEM project aims to create a local marketplace for flexible demand, generation and storage in Cornwall. To underpin this the project has designed and built an online market trading platform where the distribution network operator (WPD) and the electricity system operator (National Grid) can procure flexibility from distribution connected assets; allowing both supply and demand side providers to participate in trading and optimising capacity on the network.

This model of electricity trading and network operation differs significantly from the way in which the UK electricity system currently operates. Markets and network operation have historically been designed to reflect the 'conventional' centralised configuration of the system, rather than supporting smaller scale, more active local participation. Policies and regulations in place at the moment may therefore act as barriers to the development of a model which allows more local trading of power and flexibility.

UoE Involvement in the Project

UoE's remit in [Phase 1](#) was to analyse the current GB policy and regulatory environment to identify the regulatory barriers to establishing local energy markets and suggest possible solutions.

The Phase 1 report, 'Policy and Regulatory Barriers to Local Energy Markets in GB' was published in May 2018 and can be located on the UoE website (Bray, Woodman and Connor, 2018). The report identified 72 issues which mainly fell within 6 broad areas:

1. Access to existing markets (such as the Wholesale Market, the Balancing Market, the Capacity Market and Ancillary Services) which have not been conducive to small scale generation.
2. The creation of new local markets (focussing on the anticipated future role of the Distribution Network Operators (DNOs) and the services they can be expected to provide.
3. The existing trading rules and the challenges these pose to more innovative trading solutions (particularly the Supplier Hub Model).
4. Connection tariffs & rules (including curtailment of local generation by the DNOs).
5. Network Charges and the impact of Ofgem's proposed changes to network charges on small scale generation and behind-the-meter¹ (BTM) generation.
6. Data (particularly the lack of data and access to available data).

¹ BTM generation is any generation that happens onsite, on the energy user's side of the meter, such as solar PV, heat pumps, EVs and battery storage

This report constitutes part of [Phase 2](#) and concerns the expectations and experiences of the householders' who participated in the LEM project.

In total, 100 households were recruited to take part in the domestic trial which was run as part of the Cornwall LEM project. All 100 households had an independent monitoring system and a Sonnen home battery installed free of charge (paid for by the LEM project) in order to take part in the project. In addition, 54 of the households had solar PV installed at their property free of charge; whilst the remaining 46 households already had PV installed.

Three different capacities of batteries were installed across the households, depending on the household's estimated energy, the capacity of any previously installed PV array, whether the participants also charged an EV, or had any other large load appliance installed. The batteries supplied were either 5kWh (61 batteries); 7.5kWh (24 batteries) or 10kWh (15 batteries).

The householders were also encouraged to use a Sonnen App to monitor their daily electricity usage. Usage of the App is discussed in [Objective 1](#).

As part of the domestic trial, Centrica remotely discharged the home batteries simultaneously, at previously determined times and dates. This was to test the feasibility of trading the aggregated battery output into the LEM platform trials which were being undertaken with WPD and National Grid. The householders were given written notification of when these trials would be occurring. As the trials were undertaken remotely by Centrica, the householders were not actively engaged in using the trading platform themselves; although they were aware of the purpose of the trials in proving the feasibility of the LEM concept.

In 2019 UoE undertook an evaluation survey with all 100 LEM householders involved in the project. The Householder Survey included an online survey which was emailed to all participants, which was later followed up with individual interviews with 42 householders; of which 30 were conducted face-to-face and 12 were conducted by telephone. For more information on the scope and format of the Householder Survey please see the Methodology section in [Appendix 1](#).

This report outlines the results of the Householder Survey and is scoped around the following three research objectives:

Objective 1: Evaluate householders' experience of the LEM so far.

Objective 2: Identify characteristics that might define who is likely to or unlikely to engage in the provision of flexibility, energy or other services via a local energy market.

Objective 3: What might encourage people to participate? What needs to change to incentivise participation?

In parallel with the Householder Survey, UoE also undertook a survey with the business participants of the LEM project. The Organisation Survey report is available alongside the Householder Survey report.

In light of this combined qualitative analysis; along with stakeholder interviews, UoE will also provide a final project report in [Phase 3](#). The final report will detail any recommendations for policy and / or regulatory change which may be required in order to enable the development of local energy markets across GB. The Phase 3 report will be available by the end of 2020, which is the project end date.

Objective 1: Evaluate householders' experience of the LEM so far

Overview

In the online survey this objective was explored in [Section 3 Your Thoughts on the Cornwall LEM project](#) which related to the respondents' experience of being a participant in the Cornwall LEM project².

Questions 15, 16 and 17 in the online survey were very interlinked. They relate to participants awareness of their household electricity consumption patterns; whether this awareness has changed through their involvement with the LEM and whether this has led to a change in electricity usage. In order to evaluate this Q15 asked participants how often they used their battery app to check how their equipment was performing; Q16 asked if they felt more aware of their energy usage as a result of having the technology installed and Q17 went on to ask whether their electricity usage had changed.

Questions 18 and 19 asked what positive and negative impacts involvement with the LEM had on their household; whilst Q21 was free space for respondents to add any additional comments they wanted to make about the project.

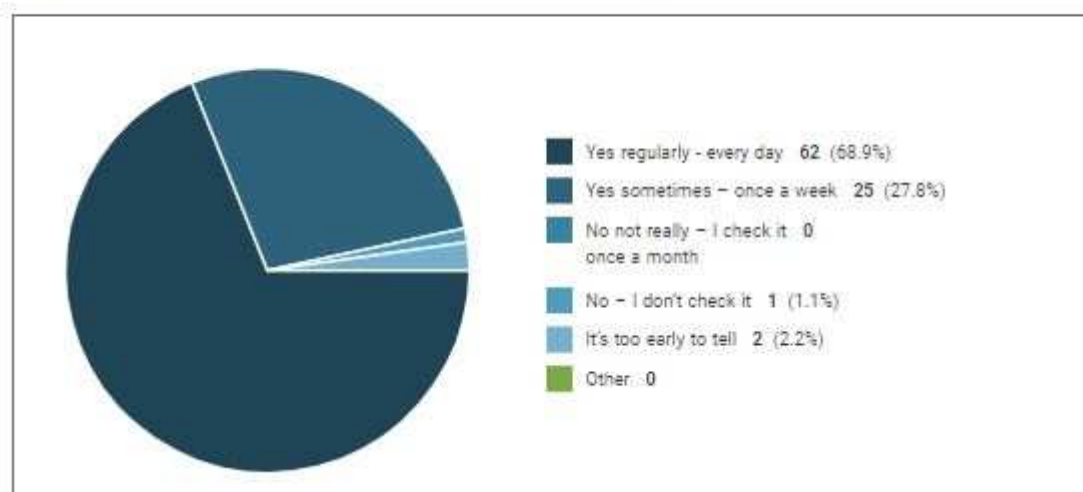
In the interviews this objective was covered by [Q2 'Describe any positive or negative experiences of being involved with the Cornwall LEM project'](#).

Results

Q15 Do you use the battery app to check how your equipment is performing?

69% of survey respondents said that they checked the Sonnen App every day; with a further 28% stating that they checked it around once a week. Only one respondent said that they didn't check the App at all, whilst two thought that it was too early to tell.

Do you use the battery app to check how your equipment is performing?



² All survey and interview questions are shown in [Appendix 3](#)

The 19 interviewees who checked the App daily were very positive about the impact that the App was having on their insight into their household electricity consumption patterns:

"The Sonnen app, it is brilliant. I mean, I literally do look at it every day."

"It's given me a bit of interest, looking at the app every day, trying to understand what it's telling me and trying to make up my own methods of maximising the benefits."

"I often use it about two or three times a day just to check what's going on."

"It's been interesting having the feedback through the app and seeing the usage patterns and the little graphs and such like."

"I can also see the bars when we turn the cooker on and the kettle. The kettle is the biggest thing. You get this huge bar for 30 seconds and then it goes down again. We watch all of that; it creates a bit of interest."

However, against this 4 interviewees expressed frustration with the App; which was combined with a frustration of not knowing how to get the best performance out of their PV and storage equipment in general (which is discussed in more detail in [Q 19](#)). These 4 people either remarked that there hadn't been sufficient training on how to use the App, or they found the App difficult to understand:

"I still would appreciate someone just to take me through just exactly what the app is telling me. Because he didn't do that, we definitely weren't taken through the app."

"We could have almost done with someone like the surveyor to come back after a month of running it to explain the app."

"If in the app, there was something which told you, you were generating more power and just flashed a light and you knew then you could turn things on. So, if it was more user friendly, maybe."

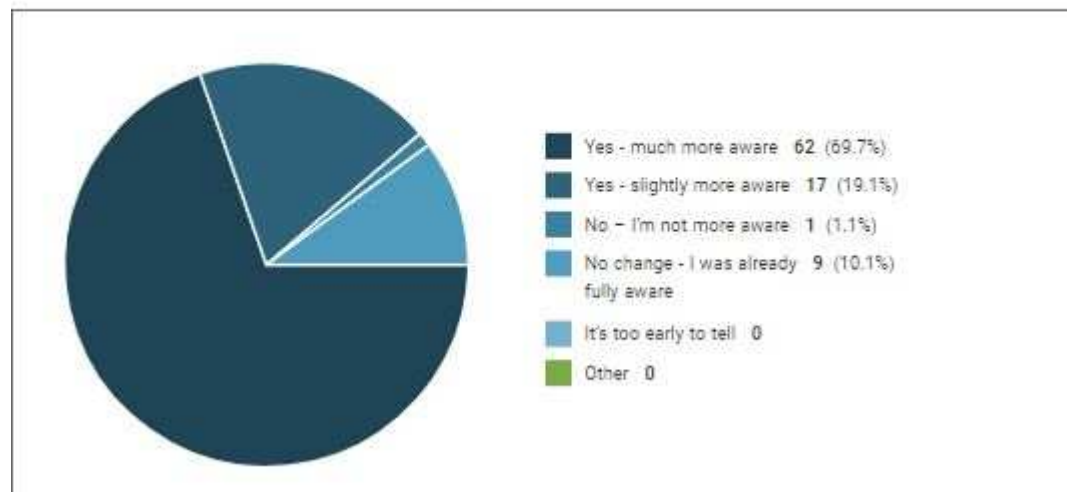
"There are some bits I don't quite understand about why sometimes I'm buying electricity when there seems to be enough generation. It must be a timing thing and the battery capacity, I'm reasoning, but I can't work it out."

The use of the battery App has therefore been a major factor in peoples' overall experience of participating in the trial; linked to their understanding of how much electricity they are generating, storing and consuming. This is important not just for recognising their own individual household consumption patterns, but also for understanding how they can contribute towards the wider aims of the LEM in regard to trading capacity (discussed in [Objective 2](#)) and their contribution towards alleviating network constraints through the development of a more flexible local network.

Q16 As a result of the equipment being installed, do you feel that you are more aware of the energy you use and generate in your home?

Q16 links directly on from the previous question with regards to peoples' understanding of consumption patterns. In the online survey 70% said that they were 'much more aware' of their energy usage and 19% said that they were 'slightly more aware' of their usage. A further 10% thought that they were 'already fully aware' of their energy usage before the LEM project. Only one respondent thought they weren't more aware – this was not the same person who reported that they didn't check the App in Q15. There were also options given for 'too early to tell' and 'other', which no-one selected.

As a result of the equipment being installed, do you feel that you are more aware of the energy you use and generate in your home?



It should be noted that 46% of LEM householders already had solar PV installed prior to the LEM project; and as such several interviewees expressed that they already had a good appreciation of how much energy they were producing and using on a daily, weekly or monthly basis.

However, as will be discussed in Q19, 15 interviewees (36%) stated that they didn't know how to get the best usage from their generation and storage equipment. This may indicate that although they may be more aware of the energy used and generated, they don't necessarily have the expertise to translate this awareness into knowing how to best optimise their system. As one interviewee expressed, there is a lot of learning for people to do to get the most out of owning and operating the technology:

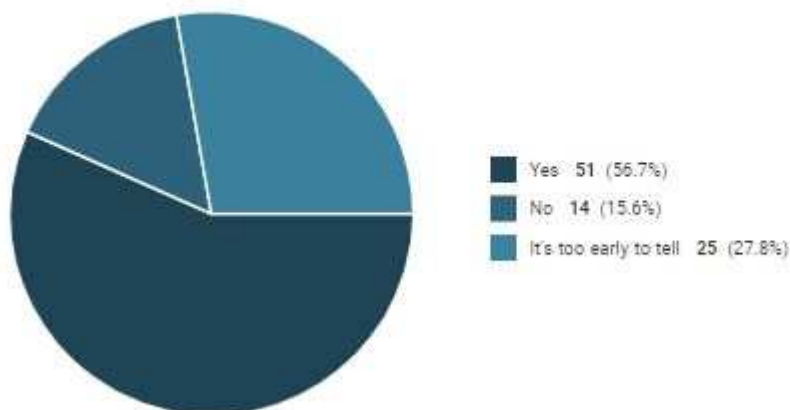
"As a user of this sort of system, there is quite a lot of learning to do... Oh yes, then you have to learn about the power usage of different items in your house. You learn about the generation capability of the system."

Further guidance on getting the most out of the system is therefore discussed in Q19.

Q17 Has the way in which you use electricity changed since your involvement with the Cornwall LEM project?

In the online survey 57% of respondents reported that their electricity usage had changed since their involvement in the project; whilst 28% thought that it was too early to tell.

Has the way in which you use electricity changed since your involvement with the Cornwall LEM project?



Domestic electricity consumption accounts for 30% of total electricity demand in the UK (BEIS, 2019b). Human behaviour patterns are therefore one of the main factors that can influence domestic electricity demand; so it is therefore important to understand influences upon behaviour in order to both reduce demand and reduce environmental impact (Pothitou *et.al.*, 2016).

The survey respondents who had indicated in Q17 that they had changed their electricity usage were asked to give a brief explanation as to how it had changed. Responses were concentrated around using appliances during times of the day when the PV was generating (especially on sunny days); being more mindful of how much electricity was being used by the household and a greater family awareness of usage.

This was also a recurring theme in the interviews with 39 interviewees (93%) reporting that the way they used electricity had changed since joining the project. This percentage is much higher than the 57% who stated that their electricity usage had changed when answering the online survey, and even for adding in the 28% who said that it was 'too early to tell' in the online survey it is still higher than the combined survey percentage of 85%. Therefore, whilst this increase can be attributed in part to the fact that the interviews were held up to 6 months after the survey had been completed, (and the respondents therefore had more time to assess whether their usage had in fact changed), it also indicates that additional factors could also have influenced behaviour change. The most probable answer to this is that the householders had been surveyed during the winter, whereas the interviews were held in August and September, when householders would have generated more of their own onsite electricity from their solar PV. Interview responses that would back this assumption include:

"You start to be quite good at weather forecasting and its impact on electricity generation. Today is a cloudy day, it's rubbish. A day of unbroken rain is really rubbish. You learn how fast the battery charges and you learn timing things, so when to switch the immersion heater on, early afternoon when the sun is shining brightly because it's free kilowatts. It's fantastic if you do it then."

"On a nice, sunny day like today, we can charge the battery up and run the house until the next day."

"I work out whether the sun is shining and are we going to fill it today or not [the battery].... Yesterday was terrific. We got all our jobs done, all our electric, standard jobs done and we still put 75-80% in the battery, so that's great."

Change in electricity usage was the most frequently mentioned positive aspect of the LEM project as given by the interviewees (see Q18). Interview comments include:

"I am more aware of the need to use electricity during daylight hours - for example to heat water, wash clothes, so use the timers on machines more. It may also have led to an overall reduction in the use of electricity throughout the house as we're now all more aware of our electricity consumption, which was an outcome I wasn't really expecting."

"We used to do all our washing on a Friday, now we do it in dribs and drabs during the week, as and when we've got surplus electricity. We used to run the dishwasher every night, religiously, but now we just leave it to the next day, when the sun shines."

50% of interviewees (21 households) already had solar PV installed before the LEM project and many of these expressed that their electricity usage had already been adapted to coincide with using appliances when the PV was generating. However, they were finding new ways of adapting this usage further with the addition of having the battery storage element included. Several expressed that this now gave them additional flexibility in the timing of when they used appliances – as they didn't feel that they had to use as much as possible during daylight hours; but could hold back some household tasks until later in the day and draw from the battery instead:

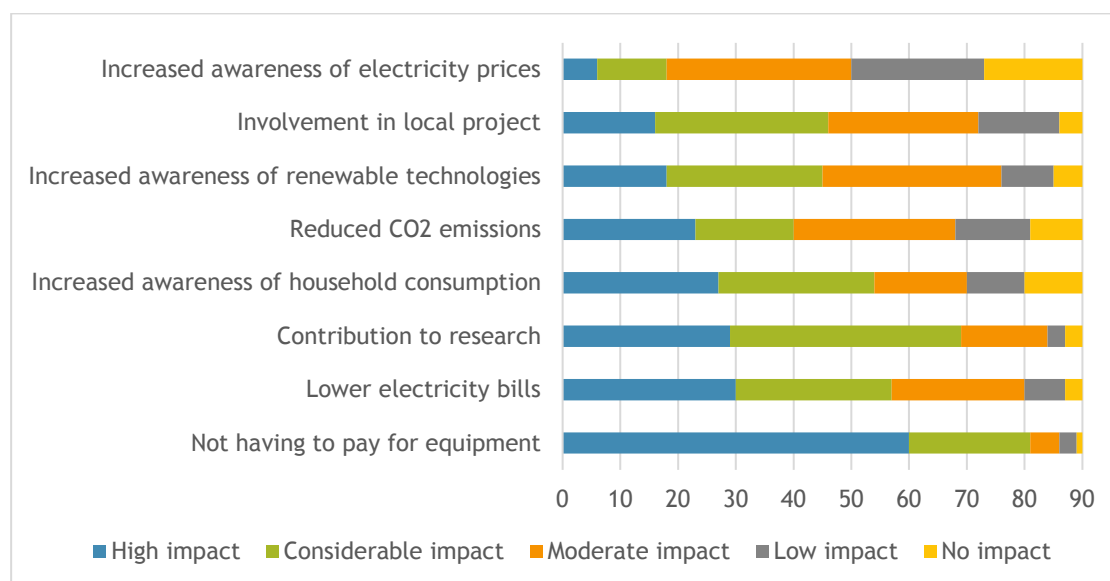
"We'd previously adapted our electricity usage due to having the PV, but now we can be more flexible with our usage as we have the battery to draw off. That really helps with having teenagers in the house and their habits. It also helps with evening usage of electricity."

"So, the habit that we'd acquired since having solar was to, if at all possible, look at when the system might be generating and then to run those things in series, one after the other. The big penny that's dropped for me is to see that actually, even on a fairly cloudy day, the battery by mid-afternoon can be almost fully charged, so we've then got decisions to make about could we use that to run the dishwasher or washing machine or decide to leave it in the battery to run lighting and TVs overnight. It sounds very, very simple, but that was a big realisation for me, that the battery was essentially like topping up a jar which we could draw on."

Q18 What positive impacts has involvement with the Cornwall LEM project had on your household?

In the online survey Question 18 gave a list of 8 different positive impacts and respondents were asked to rank these on a 5-point Likert scale between 'high impact' and 'no impact'. There was also an optional free text box for respondents to list any other positive impacts which hadn't been covered by the list; which 33 householders responded to. Responses against each factor are shown in [Figure 1](#) below which is ranked by the answers given by the go online survey respondents:

Figure 1 Positive impacts on your household (by number of survey respondents)



Other positive impacts included in the free text box included increased environmental awareness; better understanding of own energy usage; feeling involved in the project; positive impact on immediate family (within the household) and raising energy awareness with wider family, friends and neighbours.

In the interviews this question was framed slightly differently. Instead of asking for positive impacts on the **household**, the question asked about [any positive](#) (and /or negative, see [Q19](#)) [experiences of being involved with the Cornwall LEM project](#); which was a much wider question.

Although interviewees were asked to list positive and / or negative experiences many pointed out that the positives outweighed the negatives with comments such as '97% positive'; '98% positive'; whilst 16 interviewees (38%) stated that there were 'no negatives':

"We're saving money and we're part of a beneficial research project, you know, and the positives outweigh any negatives anyway."

"It's been a positive all-round experience."

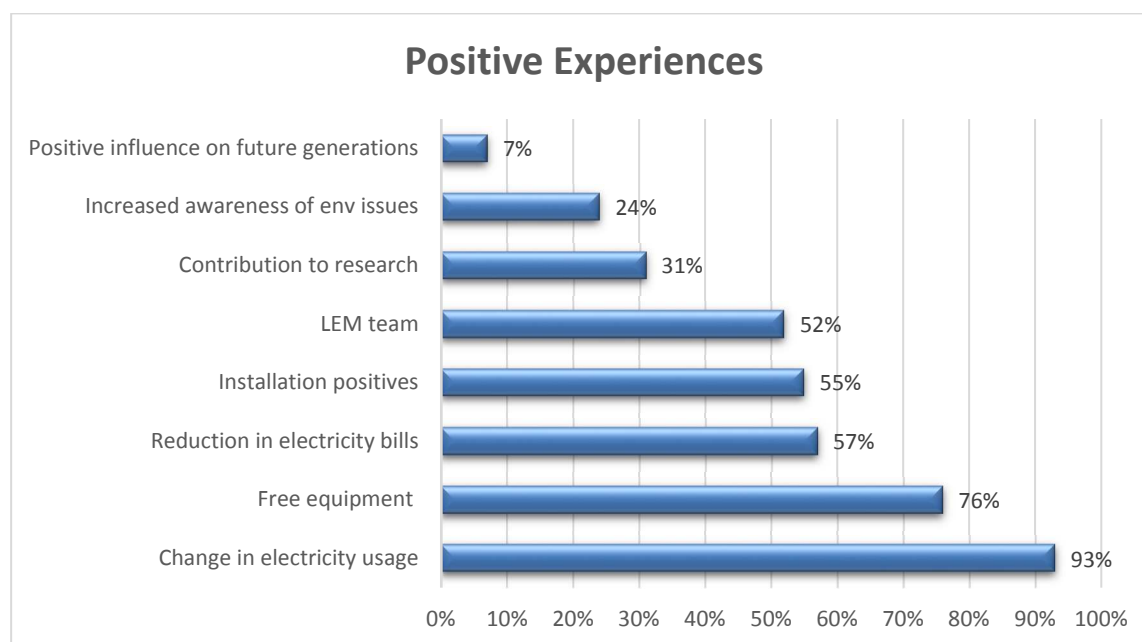
"Absolutely no negative experiences."

"For us, it's been like a real clear-cut thing, it's been great. It's been unexpectedly great, really."

"I'm afraid I can't give you any negatives, I've been really pleased to be participating."

[Figure 2](#) below shows the interviewees most frequently mentioned positive experiences. Although these have been portrayed simply by showing how many interviewees spoke of each positive experience, they can also be broken down into several sub-categories such as financial impacts; physical impacts and emotional impacts. Therefore, some of these positive impacts are quantitative e.g. their installation was a success; whilst some of the impacts are qualitative e.g. they feel good about making a contribution towards research and environmental awareness. These different motivational impacts will be explored in more detail in [Objective 2](#) when we discuss motivations for being involved in the project.

Figure 2 Positive Experiences of being involved in the trial



- **Change in electricity usage**

The most frequently mentioned positive by 39 interviewees (93%) was the change in their household's electricity usage as described in Q17 above. One reason why this may have been the most frequently mentioned positive is that it cuts across 3 sub-categories listed above – financial, physical and subjective; by bringing together the financial impact of reducing electricity bills; the physical impact of actually changing routines and behaviours to maximise energy efficiency; as well as the motivational impacts of reducing household carbon emissions; being environmentally conscious and contributing towards self-sufficiency in the home. The change in electricity usage is also the householders' main contribution towards the project outcomes which they can assert some control over; as other project factors are beyond their control such as the automated discharge of their batteries and the generation and storage capacity of their PV and battery.

- **Free Equipment**

The second most frequently mentioned positive by 32 interviewees (76%) was the fact that they hadn't had to pay for the equipment or the installation. This almost correlates to survey Q8 where 81% of respondents said that having their technology installed for free was either very important (44.4%) or somewhat important (36.7%) in their decision to join the LEM (which will be discussed later in Objectives 2 and 3 when we discuss motivational factors).

Interview responses include:

"Positives, I still can't quite believe that I will get such a unit for zero cost really, for having to do very little."

"It was a big bonus that we were gifted the system. It's a fantastic gift."

"To be offered a free battery was an opportunity not to be missed."

- **Reduction in electricity bills**

By the time of the interviews (September 2019) 24 interviewees (57%) said that they had seen a reduction in their electricity bills, whilst others expected to see reductions on their next utility bill. Some interviewees discussed the link between their change in usage and the financial benefit this bestowed; whilst others only mentioned the financial benefits of having the generation and/or storage technology offsetting what they would normally have procured from the grid:

"It's quite enthralling to see the electric bills going down every month when I put the new meter reading in. And it's like as if there's more of a challenge now, to see if we can get it down any further"

"It's significantly reduced our energy costs with regards to electricity. It's come down, I don't know, 80% potentially."

"My expected electricity savings are around £30 per month. I also charge my hybrid car when the battery is full so I get a free charge which is another saving of around £50-60 per month."

"This month was £18, including the standing charge. The previous month it was £12 for the month... Sometimes, before, we might have been spending £70-£80 a month, maybe even £100 in winter. It's brought it down significantly."

- **Installation positives**

23 interviewees (55%) praised the installers, the installation process or the quality of the technology; with 5 interviewees explaining how the installers had gone 'the extra mile' whilst at the property e.g. by spotting leaks; replacing broken tiles and ensuring that garden access wasn't impeded by scaffolding. General comments included:

"Yeah, the installers were very good, very efficient, didn't intrude on anybody, got on with it."

"The two guys that were here on different occasions were both - you'd have been proud to introduce them to your mum - they were lovely."

"The installation went very well, yeah, it all went like clockwork"

Several householders had also researched the Sonnen batteries prior to the install and were impressed with the quality: -

"I thought, knowing my luck, they'll be free, which is brilliant, but maybe they won't be as good a quality, but no, I did look at it and no, they are good. Sonnen are a really professional company."

"The battery is a quality product, from Germany; it wasn't just a cheap battery."

- **Centrica LEM team**

22 interviewees (52%) praised the Centrica LEM team for communications and support during the project; and 18 survey respondents passed on their thanks and appreciation to the team through the additional comments box. Comments included:

"The team at Cornwall LEM has been very helpful and conducted themselves in a professional manner. I believe they have been an asset to the success thus far."

"Couldn't believe how good they were"

"The people that are running it are doing brilliantly."

"The Cornwall LEM team has been very helpful whenever I've spoken with them, professional and courteous. Our thanks for involving us in the project."

"Thank them for the work to arrange for all this to be installed for me."

"Very lucky to be participating and privileged to have had the opportunity."

- **Contribution to a research project**

13 interviewees (31%) expressed that they were glad to be involved in a research project which they considered to be worthwhile. These participants particularly valued the contribution that they were making towards proving the local energy market concept and the future potential of the concept to both improve uptake of renewable energy in Cornwall and improve grid constraints:

"It is really nice to be part of something that is so forward facing, part of something that could be the future of how we do power generation and consumption in the country."

"The positive is just the notion that I'm involved in something worthwhile."

"I want to see the results of the trial as a whole. There's a broader picture that I want to see a success and I want to be part of the bigger success, not just a personal one."

"And knowing that we are contributing to what hopefully is valuable research and what might come out of that. Gives me a warm glow. It's true though, isn't it? It's nice to think that you're doing something that's a contribution."

"You're involved with a project with 99 other people and businesses in Cornwall. You're part of a much bigger collective - that can only be good for everybody... It wouldn't be such a benefit if I had just gone and bought a Sonnen battery and sat here monitoring it and rubbing my hands and thinking oh, this is good, I'm becoming more self-sufficient."

As will be shown in [Objective 2 Q10](#), 94% of survey respondents also stated that they were motivated by Centrica's animation of how a smart and flexible energy grid in Cornwall could operate in conjunction with a local energy market.

- **Raised awareness of environmental issues**

As will be shown under [Objective 2](#), many of the householders already had an interest in renewable technologies as a way of reducing their usage of fossil fuels in order to mitigate against climate change impacts. As we already know, 46% of the householders had installed solar PV themselves prior to involvement in the LEM.

However, 10 interviewees (24%) and 18 survey respondents (20%) reported that they had a wider awareness of environmental issues due to participation in the project. This included both those with and those without solar PV already:

"From the point of view of raising our overall awareness of our environmental impact and trying to change bits of our behaviour where we can, trying to recycle more, being more conscious of what we're purchasing and, potentially, what kind of impact that is. Yes, I'd say it's had a fairly substantial impact on us."

"Increased our awareness as a household of our part in the challenge to combat climate change and human impacts both locally (beach cleans, more recycling) and globally (change of summer holiday so no flying and high levels of CO₂)."

- **Positive influence on children / future generations**

Three interviewees (7%) and 8 survey respondents (9%) mentioned the positive influence of the project on their children and the fact that the project has created greater family awareness of renewable technologies and environmental issues:

"We have young children, who are going to need to be aware of the impact of green technologies in addressing the climate crisis, and they can see that we are involved in a scheme that is helping to address this issue"

"Renewable and sustainable energy production will be key for my children's future, so to be involved in a project that can help define best practice, lead to greater uptake of technology and drive forward changes to make the future brighter and more positive for my children is a huge motivation."

"As responsible parents and people who love the planet it's looking at what we can realistically do, and this was something"

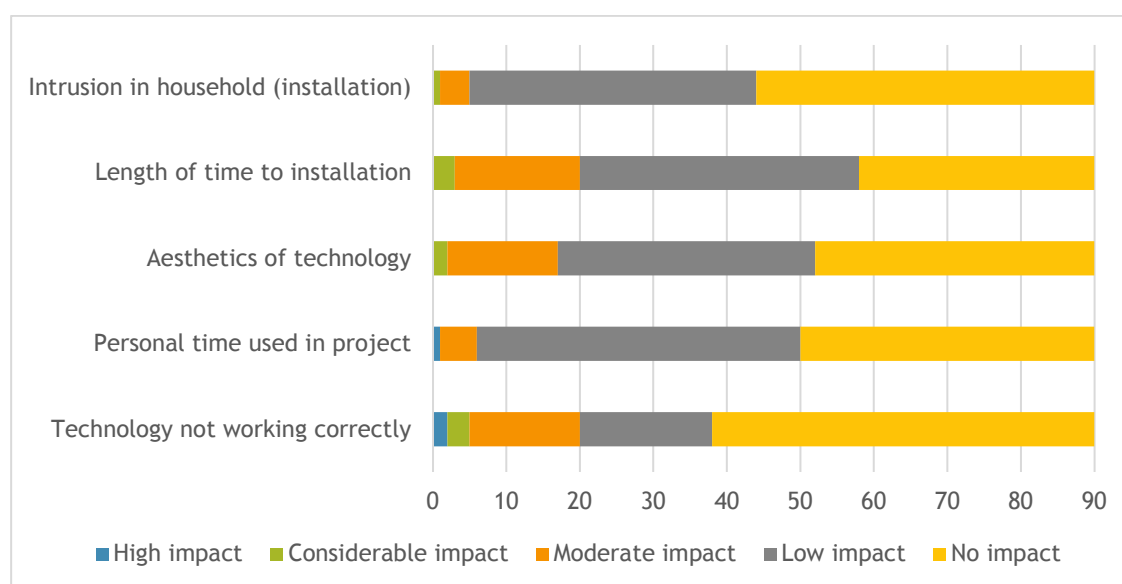
"My oldest daughter, she's challenged her school with why didn't they have lights that were on smart sensors for the toilets and things. Which they now do, so I think it has kind of had that broader impact, as well."

Q19 What negative impacts has involvement with the Cornwall LEM project had on your household?

Question 19 gave a list of 5 different negative impacts and respondents were asked to rank these on a 5-point Likert scale between 'high impact' and 'no impact'. There was also an optional free text box for respondents to list any other negative impacts which hadn't been covered by the list; which 29 householders responded to (although 8 of these responses stated that there were no negative impacts).

Figure 3 below shows the full responses given per impact. No-one selected 'high impact' in 3 out of the 5 categories. The two negative impacts which did score in the 'high impact' fields were 'personal time used in participating in the project' (selected by 1 respondent) and 'technology not working correctly' (selected by 2 respondents). Personal time used in participating did not factor as an issue in any of the interviews undertaken; however householders had the choice not to be interviewed if they didn't wish to be. Twelve interviewees stated that they had experienced technical issues as discussed below.

Figure 3 Negative impacts on your household (by number of survey respondents)



Other negative impacts reported in the free text option included issues to do with the batteries either being noisy or bulky; the Householder team at Centrica not being well informed or able to resolve difficulties easily; installation and teething problems; and technical (mainly internet) issues and problems with meters running backwards.

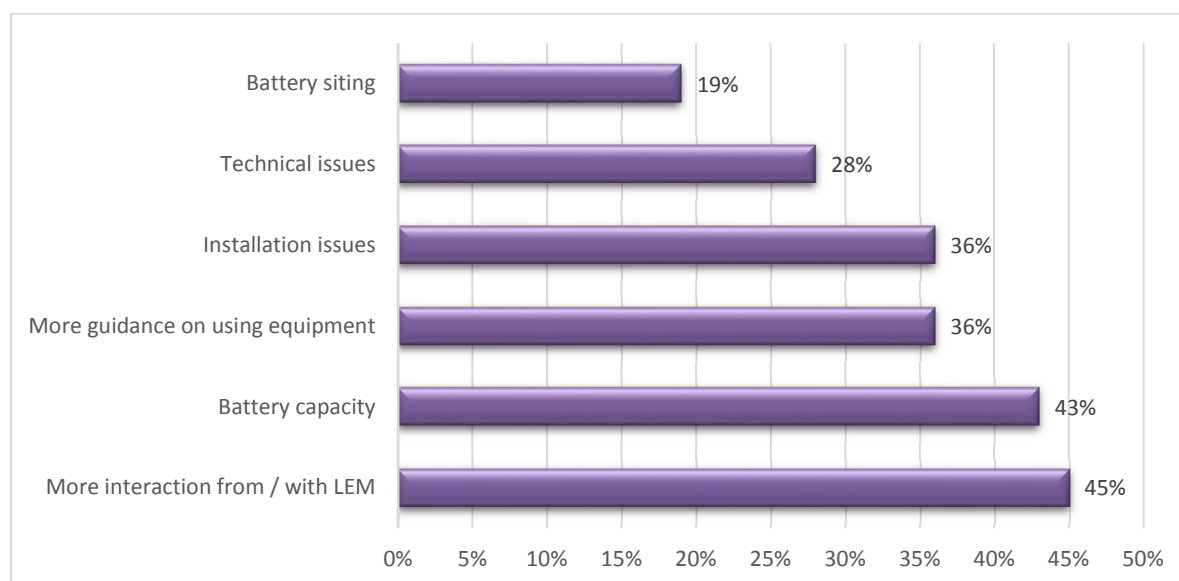
As in Q18 above, this question was framed slightly differently in the interviews. Instead of asking for negative impacts on the household, the question asked about [any negative experiences of being involved with the Cornwall LEM project](#).

Despite the comments in Q18 above about 'no negatives' and 'positives outweighing the negatives' it is a reality that some householders have experienced negative impacts which either have had a short-term detriment; or could potentially have a longer-term detriment on the householders' experience of the LEM project.

Figure 4 below shows the interviewees most frequently mentioned negatives. Again these have been portrayed simply by showing how many interviewees spoke of each negative experience. However where these experiences differ mainly from the positive experiences is that most of these negative experiences are quantitative e.g. issues with installation of equipment or technical issues; whilst the

remaining negative factors are more related to perception and could possibly have been overcome within the project period had the Centrica Householder team allowed additional resources to be aimed at training and communicating with the householders.

Figure 4 Negative Experiences of being involved in the trial



The most frequently recurring negatives concerned the Sonnen batteries, which we have split into 2 categories; siting issues and capacity issues.

- *Battery (siting)*

Longer term issues include the siting of the battery within the house; causing noise and / or light nuisance and / or taking up space within the house. Five interviewees expressed strong negative opinions regarding the siting of the battery within the house. Of those five; 2 related to both noise and light nuisances; 2 related to just noise and the fifth related to space issues. In addition, there were a further 3 interviewees who expressed some dissatisfaction at the noise levels; but who didn't find this to be overly detrimental. Those that commented on noise reported:

"There is a noise issue. Sonnen have a video showing their batteries in somebody's living room. I can assure you, it would be a big deal if it was in my living room. Because not only is it noisy, it pulses, the light pulses".

"There is quite considerable noise. Not only of the cooling fan but in terms of a strange sort of, quite intrusive tweeting sound when the electricity is being drawn. That's quite noisy; it's like a flock of birds in the room".

"Had I known how noisy it is I'd have put it in an outhouse. I'm glad that Centrica haven't discharged it during the night as it would have disturbed us. I know exactly what it's doing all the time as I can tell from the noise".

Two of the interviewees are seriously considering paying to have the batteries moved when the project ends. One interviewee who will be looking to move the battery was told by the surveyor that the battery could have been installed in the garage but that it would have been more expensive to install:

"He said, [the surveyor] 'you could have it over there, but you'd have to pay. If you were doing it yourself and paying yourself, then you'd just pay the guys to put the electricity cable across the house, through the roof or whatever, and down.'" He says, "There's no benefit to have it over there, apart from the fact it's a lot cheaper to install for them." Which I can see that, we're not paying, so you know, we have to go with what they're doing, that's fine."

- *Battery (capacity)*

Other battery issues are that some householders feel that they haven't been given enough storage capacity with the size of battery installed. This was raised by 18 interviewees (43%) who saw this as a negative issue. Three different capacities of batteries were installed across the households, depending on the household's estimated energy usage and whether the participants also charged an EV at home or had any other large load appliance installed. The batteries supplied were either 5kWh (61 homes); 7.5kWh (24 homes) or 10kWh (15 homes).

However, dissatisfaction with battery capacity has led several householders to investigate whether they can purchase additional units to add-on at a later date. The overall feeling is that the householders would prefer more autonomy from the grid, which they feel is being hampered by the smaller capacity batteries. This has also affected some participants' willingness to engage in the concept of trading excess generation as they feel that they don't have enough spare capacity to make trading worthwhile for them (see [Objective 2](#)).

"Another negative, we could have a bigger battery and that would mean we could store even more... We could easily hold more or feed back in, depending on obviously what the market would require."

"I'm handicapped because I've only got five kilowatts... I'm a bit annoyed at that."

"We're just wondering whether if the size of the battery maybe is what affects the autonomy, whether our capacity for storage, something like that is less. I don't know."

"We could have saved more money on our bills if the battery had been bigger so we might get a bigger battery after the project."

"I can't see a 5kWh battery working particularly well – it doesn't have any potential to trade."

- *More communication and involvement wanted from (or with) the LEM team*

A recurring theme from the survey was that the householders wanted more communication of outputs from the Centrica LEM team. This was raised by 19 interviewees (45%) and was also included within the comments sections of the online survey by 18 householders (20%).

The discrepancy in results may have arisen due to the fact that the interviews were held either 7 months or 4 months after the online survey was completed (depending on whether the householders were surveyed in the February or May cohort); which meant that they were possibly feeling increasingly more disengaged by the time of the interviews. It is also worth noting that of the 18 comments raised by householders during the online survey, only 2 of these comments were raised in the 'negative impacts' section; with the remainder raised in the 'additional comments' section. These 2 comments both related to the LEM team being not very well informed initially and therefore unable to help with queries.

The majority of issues raised concerned the lack of communication from the LEM team regarding progress of the project and associated project outputs. This was then expressed as a sense of not feeling adequately involved in the project (or as involved as they wanted / expected to be).

Several householders also expressed confusion over what the local energy market concept actually meant for them as individuals; or to the energy system in Cornwall as a whole.

"Overall we feel unloved. We feel like neglected children where the parent throws lots of money at you, but doesn't bother to spend any time with you."

"On the negative side, I didn't think anybody would want to put in a system that obviously costs so much money and then just basically left us to it. I expected a lot more interaction between the project and myself....in some ways I don't really feel as if I've been part of a project, if you see what I mean?"

"At this stage of the journey I expected to be an absolute expert on all of this and I'm just, I still feel like a novice."

"It's only been poor with respect in not knowing whether or not, what is actually happening with the local energy market and the battery. I haven't got a clue."

"I've seen the tests go on and I understand what those tests are doing, but the whole programme was going to deliver a portal and a way of trading energy. Everyone, I think, is completely in the dark as to what that might look like. Financially how it might stack up or how involved that might be. I think that's probably the thing that's missing, from my perspective."

On a separate but interlinked theme some survey respondents and interviewees also hoped that the project would have been more participatory between the other LEM householders, with the establishment of either a Facebook page or forum for participants to share hints and tips on maximising performance and also to get advice from others on troubleshooting any technical problems.

"I expected a Facebook page where we could all sort of exchange ideas, experiences, what have you."

"I thought a Facebook page, (or similar) for participants to exchange ideas and opinions would have been a good idea. It's great to take part in a local project, but you have to feel that you are an active member of that project."

"I sort of hoped there'd be like a workshop where you could, like frequently ask questions. The sort of things I'm asking, where a hundred householders could have come together and said... the things I'm asking, other people might be interested and they might be asking things that I would think, oh, I hadn't thought of that."

- *More guidance needed on using the equipment*

The next most frequently mentioned negative also resolved around communication from the LEM team; but directly concerned not feeling adequately informed about troubleshooting any technical problems or being taught how to get the best use out of the equipment and / or the Sonnen App. This was identified by 15 of the interviewees (36%).

Although the householders were provided with a manual from Sonnen on how to use the battery, several found that they had to do their own internet searches to learn basic advice; particularly around what the different coloured lights on the front of the battery signified:

"The manual could be better; the manual doesn't tell you much. What it doesn't tell you at all, I don't think, is the lovely whirly coloured lights on the battery pack, I think signify things. They signify status, but it doesn't explain them, which is frustrating."

"I downloaded this stuff from the internet and it explained about the lights. It showed that if it was showing red all the time, it wasn't working."

"The static light, it can also change colour from blue to red. If it changes to red, I had to find out, but it means it's not working. I had to find that out. And I had to find out what you do"

People also felt that they weren't getting maximum efficiency from their PV and batteries due to a lack of understanding of when to use appliances; when to draw from the PV and when to store / discharge from the batteries to get maximum performance.

"I don't think homeowners or battery owners have been provided with tips on how best to utilise the battery."

"The main thing, I think, is to make everybody more efficient and optimising what they are generating. It would be quite nice to because I don't know where I am, not so much in my generation, but am I optimising it well?"

"Centrica have been data harvesting from people who didn't know how to use the battery. I didn't even know the basics on how to use it efficiently. For instance, if the battery was 45% full what is the most efficient way of using that energy – should I use it now to bake a cake or something; or should I wait until the battery is full? If I'd been educated on how to use the battery earlier in the project I would have had better usage earlier in the project."

"Maybe it would have been helpful just to have guidelines of when to switch things on and how to get the most out of it, really."

"If I'd bought the system for however much it was, £5,000, £10,000, £15,000. I'd be incredibly disappointed now. Does that make sense? I don't know enough really about how the system works."

This then led to concern from one householder that the trial data won't therefore be as robust as it could have been.

"The data is limited as its coming from people who didn't know what they were doing. The data isn't representative of informed decision making. In fact, maybe it would have been better to split participants into 2 groups – the informed and the uninformed to compare the data analysis between those 2 groups."

Much of this criticism could have been addressed sooner in the project either through written guidance on optimising battery usage; or through a workshop style event where Centrica explained how the batteries work.

Installation issues

15 interviewees and 8 survey respondents reported that they had encountered issues with the original installation. This does not include the battery siting issues discussed earlier.

One householder was particularly disappointed with the cabling work which wasn't carried out to the original specification agreed with the surveyor; and who is now left with unsightly cabling which has caused an unnecessary frustration:

"He'd [the surveyor] worked out a way that it should have been done and it didn't get done that way, presumably because it was easier not to do it that way and they could do it a quicker way."

However, because the equipment and installation were provided for free, there was a feeling with some participants that they shouldn't complain when an issue occurred. Six interviewees (14%) expressed that they haven't complained about an issue because the benefit of having the free technology installed outweighed the negative impact of the issue. In each case these were issues that the participants would have tried to resolve if they had been paying for the service themselves:

"The 1% demerit would be that... it's not even Centrica or the local energy market, it was the installation process... What was frustrating, ever so slightly, was the feeling that we're getting all this kit for nothing, we really shouldn't complain."

"We know that there's a certain amount of money that's allocated to it and you can't do everything, you know, we understand that it's constrained. And the benefits that we get are too much to complain about really. We're getting a free battery."

Other installation issues were recognised by the installer at the time of installation; usually regarding the connection of the monitoring equipment:

"There was some technical glitch, it wasn't registering back at the centre, so he had to come back and do another major refit three or four weeks later. Then they came back again because it still wasn't quite registering. We've had several interventions really."

"Just thinking in terms of, if this was ever rolled out more widely, if it needed that level of data logging, it either needs more training for the installers or it needs a slightly simpler system. It was one of these things where man on the ground, man at the sharp end confronted with a box that didn't want to do what it said it was going to do, spelled trouble."

One interviewee who had several attempts at trying to get the monitoring equipment connected reported that an installer walked away after accidentally disconnecting the household internet connection:

"After an hour, he walked out. And it wasn't working. So, it wasn't monitoring what he'd come to do...there must be a record somewhere of who it was, because I wouldn't have him back in the house. He said, "No, that's nothing to do with me." I said, "It is to do with you. Because you've just pulled the wires out and stopped it working."

Other installation issues related to equipment not working correctly initially and this not being picked up either by the householder or Centrica for some time afterwards.

"We had one glitch with the install. They wired up 2 x 7 panels, but when I compared our performance with a friend I found that they were getting twice as much. We then found out that one of the cables was incorrectly fitted from the start – but it took about 4 weeks to notice."

"The installers wired up my meter incorrectly and it took 2 weeks to sort it out."

- *Technical issues with equipment*

After installation, several householders experienced technical issues with their equipment. This was usually either with the equipment going offline; or the battery not charging properly after Centrica had completed an automated discharge of the battery during trialling.

However, most householders who reported a technical issue only saw this as a minor negative issue because they were very pleased with how the Cornwall LEM team responded quickly and were helpful in resolving technical issues. These householders now know what to do if the problems arise again:

"It's turned itself off for a couple of times and I get very useful help from Jayne or whoever is on the other end, so you know, that's very positive as well. Whenever anything isn't slightly right, it's easy to see. And it's easy again to see because the app is there, and I look at it, and it's, oh, something isn't right here."

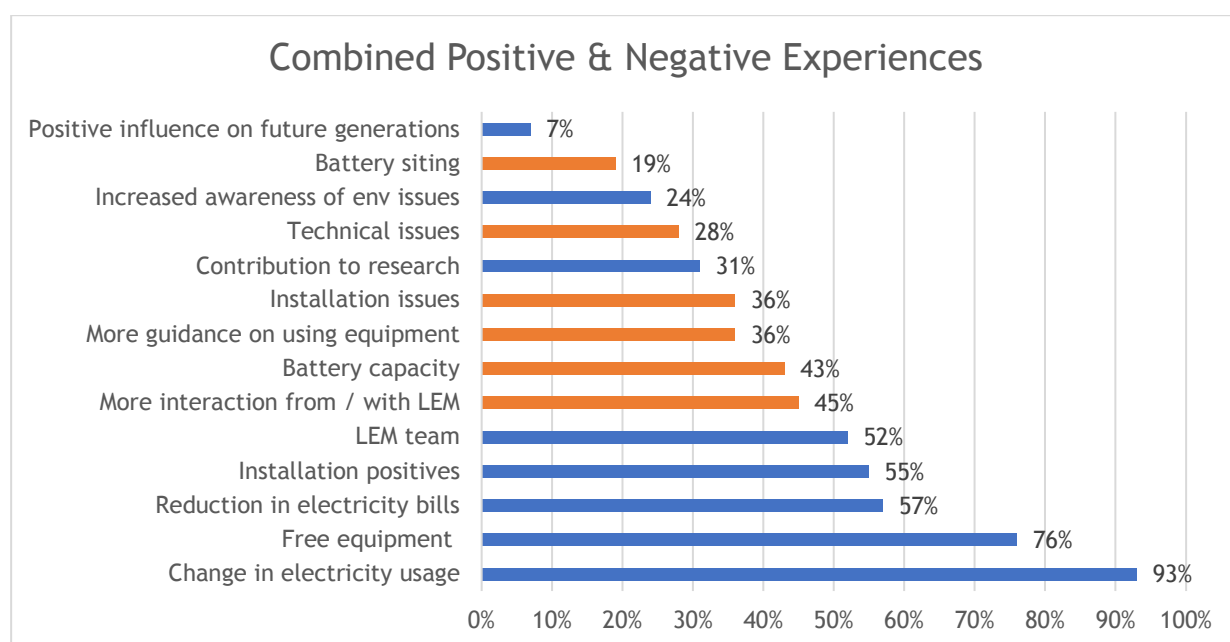
"I did notice one day that after some tests it wasn't discharging. I got in touch with the team and within an hour they'd sorted it."

"There's been a few instances of it going offline But I've learnt how to do a 'hard restart'."

Analysis of Objective 1

As shown above there have been a range of both positive and negative impacts experienced by the householders in the trial. However, when evaluating the scale of these impacts, the positive impacts have generally had a significantly higher impact than the negatives. This can be shown through the online survey responses where all of the positive impacts (8 given impacts) scored in the 'high impact' fields whilst only two negative impacts (out of 5 given impacts) were scored as 'high impact'. This can also be shown by the interview data which accumulatively mentioned 166 individual positives as opposed to 87 individual negatives; along with comments such as '97% positive' and '98% positive' which accompanied some of the negative responses. The combined data showing the positives and negatives in relation to each other is shown in [Figure 5](#) below.

Figure 5 Combined Positive & Negative Experiences



Overall, the householders were thankful for their free equipment and for the opportunity to take part in the trial. The biggest positive outcome came from the tangible everyday change in electricity usage, combined with the increased awareness of how electricity was being used within the household and the corresponding reduction in electricity bills. Through the Sonnen App in particular, householders were much more aware of their household consumption patterns. As noted earlier in [Q17](#), as domestic electricity consumption accounts for 30% of total electricity demand in the UK (BEIS, 2019b), human behaviour patterns are one of the main factors that can influence domestic electricity demand; therefore it is important to understand influences upon behaviour in order to both reduce demand and reduce environmental impact.

In several cases participation in the Cornwall LEM also led to an increased desire to make other pro-environmental behaviour changes, such as recycling more and being more aware of personal travel decisions. Pro-environmental behaviour is a form of environmental action that seeks to minimise the negative impact of one's actions on the natural and built world and refers to personal actions that are directly related to environmental improvement; whether performed individually or collectively. Pro-environmental behaviour can be influenced by both internal factors such as environmental awareness

and attitudes - an individual's 'moral code'; and also by external factors such as finance, peer groups and work environments (Pothitou *et.al.*, 2016).

As will be shown in [Objective 2](#) there were several different internal and external motivating factors for the householders initially wanting to be involved in the trial apart from just financial gain. In addition, whilst some of the householders' experiences of the trial can be attributed to external qualitative factors (e.g. reduction in bills); other experiences are more qualitative and can to some extent be attributed to the householders' original perception of the LEM project deliverables.

In several areas therefore the participants' viewpoint of whether the trial had been successful or not, and their perception of the positive or negative impacts of the trial, derived from how they personally considered the LEM had delivered against this initial personal motivation. For instance several participants with a motivation towards research felt positively about contributing toward the project's wider research outputs; whilst others with the same motivation towards research felt frustrated that they hadn't been more involved in developing the project's understanding of how a local decentralised energy system could operate in practice.

This and several of the other negative experiences could have been rectified by the Centrica LEM team allocating additional resource to concentrate on communication and training. Although over half of the interviewees were very satisfied with the level and quality of the communication received; 45% of interviewees wanted more interaction from the LEM team and 36% wanted additional guidance on how to get the best use out of their equipment. In response to this feedback, the LEM team hosted an event for the householders in February 2020 to provide an opportunity to learn about the project outcomes and to be able to ask any outstanding questions. However more communication earlier in the project could have alleviated many of these concerns.

In addition, the concerns raised regarding battery capacity might have been resolved earlier if there had been more feedback from the LEM team in respect of why certain capacity batteries had been installed and the impact of this on consumption patterns. It is however noted that all householders received their individual consumption data in February 2020, prior to the householder event which should have mitigated this concern.

This should not however detract from the level of negative impact experienced by a proportion of the householders due to battery siting. In any future rollout of the LEM therefore noise and light impacts should be taken into account at the initial property survey stage to ensure that all possible avenues for siting have been explored with occupants prior to installation.

Objective 2: Identify characteristics that might define who is likely to, or unlikely to, engage in the provision of flexibility, energy or other services via a local energy market.

The Householder Survey undertaken by the University of Exeter forms only one part of evaluating Objectives 2 & 3. Alongside the Householder Survey we also undertook an Organisation Survey with the businesses who participated in the Cornwall LEM project. Therefore, we recommend that both surveys are read in order to gain a fuller perspective of Objectives 2 & 3.

Overview

In the Householder online survey Objective 2 was explored through questions 8, 10, 11 and 12.

Question 8 asked respondents to rank the importance of 8 factors relating to why they may have wanted to join the Cornwall LEM project. In Q10 we asked the respondents to watch a short video clip which was designed by the Cornwall LEM team to show how a smart and flexible energy grid in Cornwall could operate in conjunction with a local energy market. We then asked the respondents whether this concept motivated them and why.

Q11 asked respondents to rank their preferences of what they would do with the electricity stored in their home battery after the end of the LEM trial; whilst Q12 asked whether people would be more interested in trading their excess generation through an automated service or whether they would prefer to trade independently; and why.

In the interviews Objective 2 was explored through Q1 'What was your main reason for wanting to be involved in the Cornwall LEM project?' And Q3 'At the end of the LEM project would you be interested in trading your excess generation?'

In the results section below we have divided the responses into 2 separate categories - Motivations for joining the LEM and Motivations to Trade - to aid clarity.

Results

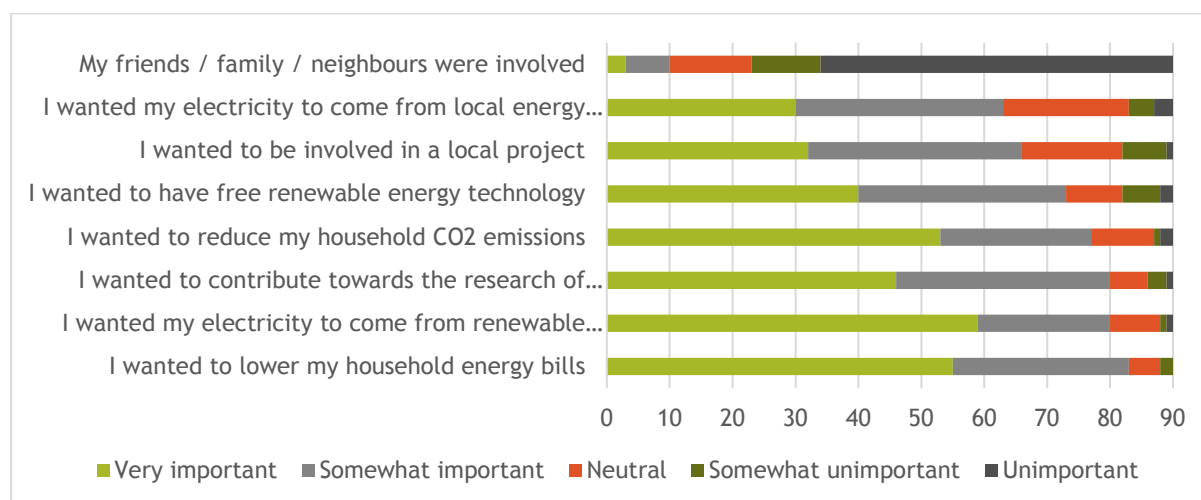
1. Motivations for joining the LEM

Q8 Please indicate how important each factor was in your original decision to get involved in the Cornwall LEM project.

In Q8 of the online survey we gave 8 possible factors for why respondents had chosen to be participants in the LEM project; and we asked them to rank these factors by importance to their household on a 5-point Likert scale ranging from 'not important' through to 'very important'.

The factors which scored highest in the 'very important' category were: 'I wanted my electricity to come from renewable energy sources' (67%) and 'I wanted to lower my household energy bills' (61%). When combining the 'very important' scores with the 'somewhat important' scores this led to 92% seeing lowering their energy bills and 91% seeing electricity from renewable sources as important factors for joining the LEM. This is a recurring theme given throughout the online survey responses and the interview responses, that both environmental and financial factors are dually important to the householders. [Figure 6](#) below shows the full range of responses given for each factor.

Figure 6 Motivations for joining the LEM (by number of survey respondents)



There wasn't an option for 'Other' or a text box for making additional comments on this question. Therefore, this question was asked within the interviews in order to assess any other emerging factors or characteristics of why people wanted to be involved in the project. However, in the interviews the question was rephrased as "What was your main reason for wanting to be involved in the Cornwall LEM project?"

It was hoped that by asking for the 'main reason' it would focus people's thoughts on their top personal priority, but time was also given for interviewees to expand on this if they wished to. Through the interview data it became evident that there were five recurring motivational factors which had led people to initially become involved in the LEM project:

- Financial motivations
- Environmental motivations
- Innovation / research motivations
- Technology motivations
- Community / social motivations

These 5 factors were not mutually exclusive; with householders generally identifying with a minimum of 2 factors. Therefore the percentages given in the motivational categories below add up to more than 100% due to people identifying with more than one motivational factor.

As one interviewee expressed:

"It's an idea that can appeal to all different sorts of motivations. The base one of just saving money, great, but if you're interested in reducing your carbon footprint, it does that. If you're interested in balance of power between consumers and suppliers, it plays a role in that, yeah."

Seventeen interviewees (40%) indicated that their primary motivation related either to their current career or a previous career (including those now retired). Those 17 interviewees span all 5 of the motivational categories. Motivations also related to voluntary work undertaken in their local communities and other direct personal experiences such as higher education courses, family and social group influences and their political motivations. Direct quotes of these references are not given in this report as that could compromise interviewee anonymity.

- *Financial motivations*

As already stated in [Objective 1](#), 76% of interviewees saw the fact that they hadn't had to pay for the equipment or the installation as a positive of being involved in the project. During the interviews 20 interviewees (47%) stated that the financial motivation of the free equipment was a determining factor for joining the LEM project and 7 interviewees (16%) stated that reduced fuel bills was a determining factor:

"When I read it, I said [to my partner] 'that is the opportunity to get £10,000 to £12,000 worth of kit with no capital outlay, with the potential to save 50% off the annual electric bill, at least. Just to let you know, I'm filling this in and sending it off.'"

"It was an understanding of the technology and its possibilities and revolving pound signs in front of my eyes."

"You want to try to be nice and not mention the money. But it was always a big kicker, it was a big incentive, I must admit."

"Certainly the incentive for me was the solar panels being provided for this experiment, I don't mind taking part in it but there was a degree of, shall we say self-interest in it. I can't deny that."

"It was something for nothing... Yeah, I mean, I think that was the main driver. If you want one answer, that's the one answer."

However, financial motivations were rarely mentioned as the sole motivator but were usually combined with either environmental motivations or innovation / research motivations. It should be considered that 50% of the interviewees had already had PV arrays installed prior to joining the LEM project but hadn't been able to commit to the additional expense of installing a battery. This was either because they couldn't afford the additional outlay; or had been advised to wait for battery costs to reduce before purchasing. For those interviewees the financial motivation of joining the LEM was therefore high, but many saw the addition of the battery as contributing to their home's existing environmental credentials:

"I mean the idea of a free battery installation was sort of a big motivator in that as well. I'd always seen that having a battery was sort of an expensive luxury that we'd never be able to take up because of the cost."

"I mean for a free battery, I'd go again because it was something we wanted that we couldn't add up."

Another factor in the financial motivation was people's age, with some retirees expressing the viewpoint that they wouldn't have seen any financial payback on the cost of the equipment within their remaining lifetime:

"Well, I've always wanted solar panels, but really at our age, with the usual financing systems, you would never recoup everything."

As will be shown in [Objective 3 Q20](#) finance issues and the cost of installing renewable technologies was seen as the biggest barrier to people engaging with a LEM without a funding system in place.

- **Environmental motivations**

25 interviewees (60%) expressed environmental motivations as their main factor for being involved in the LEM project. This was considerably fewer than the 91% who expressed that energy from renewable sources was important in their decision to join the LEM in Q8 above. However, the interview question was intentionally framed as your 'main reason' for joining the LEM in order to ascertain the additional factors which contribute towards pro-environmental behaviour.

The 25 interviewees who expressed environmental motivations accounted proportionately from both those participants who had solar PV and batteries installed as part of the project; and those who previously had PV and so only had the battery installed; therefore no relationship can be discerned as to which group were the more environmentally motivated.

Comments made by these interviewees included:

"I wanted to have our house and our whole lifestyle as eco as possible. Obviously mainly from an eco-point of view, having less of a carbon footprint and impact on the world and how we live our lives. The whole idea is to be as green as possible."

"We were interested in green and reducing carbon footprints and all that. Obviously we've had climate emergency since that, but we were that way inclined anyway. That was really our driving, it wasn't particularly about how could it benefit us, it was more about how could it feed into the larger debate about renewable energy."

"The bottom line was we've got 12 years to go on the planet unless we do something about arresting the current state of the planet CO₂ emissions etc."

- **Innovation / research motivations**

Ten interviewees (24%) stated that a main motivator in joining the LEM project was because they were interested in the LEM concept and contributing towards the research of distributed energy. This motivation aligns most closely with the environmental motivation above:

"For us, it was always about more than just saving a bit of money. For me personally, it was a curiosity about, would a system like this actually be viable and work for a family like ours?"

"I just think that it was the future of our relationship with energy, electricity and the grid. And I thought it was... quite exciting to be involved at the very beginning"

"There's a broader picture that I want to see a success and I want to be part of the bigger success, not just a personal one."

"And also to be part of the project and to see how small scale renewables can be used; so on balance it was a good thing to be involved in."

As already stated in [Objective 1](#) previously 13 interviewees (31%) saw their contribution to research as a positive experience of being involved in the LEM trial.

- **Technology motivations**

Seven interviewees were motivated by the technology aspect of the LEM. All of these interviewees were male. For 6 of the 7 interviewees this motivation related either to a current or previous career and so some words from the quotes below have been excluded for anonymity purposes:

"I micromanage it, it gives me something to do. You've always got to have a hobby you know? Come on, boys toys!"

*"My wife will tell you I am gadget man.... My original job was ****, so I'm into electronics, you know?"*

*"I'm quite technically savvy, I work in ****, so I've got a pretty good understanding of what's going on."*

"The prospect of having a battery and seeing how a battery would actually work in practice in our household."

"I'm also quite interested in moving along with technology, the battery technology."

- **Community / social motivations**

Several of the interviewees were motivated by the future potential value of a local energy market in addressing fuel poverty and social inequalities in Cornwall, if the concept could be rolled out beyond the initial 3-year trial.

Although this cannot be expressed as a main motivator for those individuals to have joined the LEM project themselves, it is valid to include the motivation here, although it will be discussed in more detail in Objective 3 where the concept of 'community' becomes a major factor in peoples' perception of the LEM concept.

"We thought it might help other people and if it could be rolled out across the county, then it could benefit Cornwall as well."

"You need to be able to benefit the least well-off members of a community and they need to be enabled by those which have excess generation to give away."

"If this could be used for some social good, then we'd be even more delighted."

2. Motivations to trade

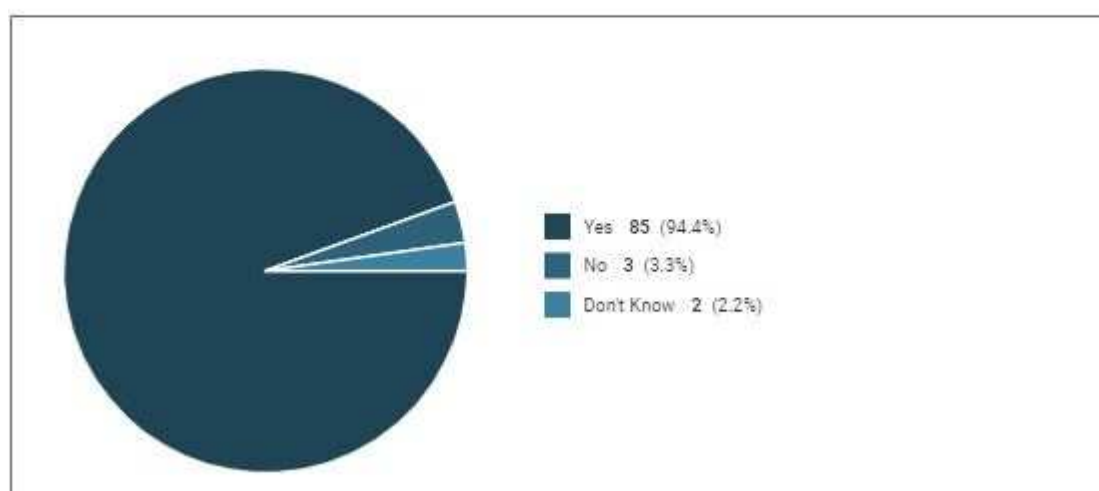
As discussed in the [Introduction](#), the LEM householders were not able to trade individually on the Cornwall LEM trading platform, rather their batteries were discharged remotely by Centrica to test the feasibility of trading the aggregated domestic battery output into the LEM platform trials which took place with WPD and National Grid.

This meant that the householders were not actively engaged in trading themselves; although they were aware of the purpose of the trials in proving the feasibility of the LEM concept. As part of our research we wanted to discover the householders' attitudes to trading; and whether they would prefer to trade individually, or whether they would prefer an automated approach similar to what they had already experienced.

Q10 Does the concept of a smart, flexible electricity grid motivate you?

In Q10 we asked the respondents to watch a short video clip which was designed by the Cornwall LEM team to show how a smart and flexible energy grid in Cornwall could operate in conjunction with a local energy market. We then asked the respondents whether this concept motivated them and why. 85 respondents (94.4%) said that yes it did motivate them; whilst 3 respondents said that no it didn't and 2 said they didn't know.

Through your involvement with the Cornwall LEM you are helping us to understand how a smart, flexible electricity grid could operate in the future which could be of great benefit to society (as shown in the video clip). Does this particular concept motivate you?



Of those that answered No to Q10 the reasons given were:

"It's a good concept but it is more about personal benefit that societal."

"We have already committed to the project."

"People's apathy"

Only 1 of the 2 respondents who opted for 'don't know' explained why they chose that option. The reason given was that:

"We have not been able to interact in any way with the virtual market set up and see what it would be like to buy or sell energy. To have a better understanding of how the market works, perhaps participants should have a more active role than just generating and storing."

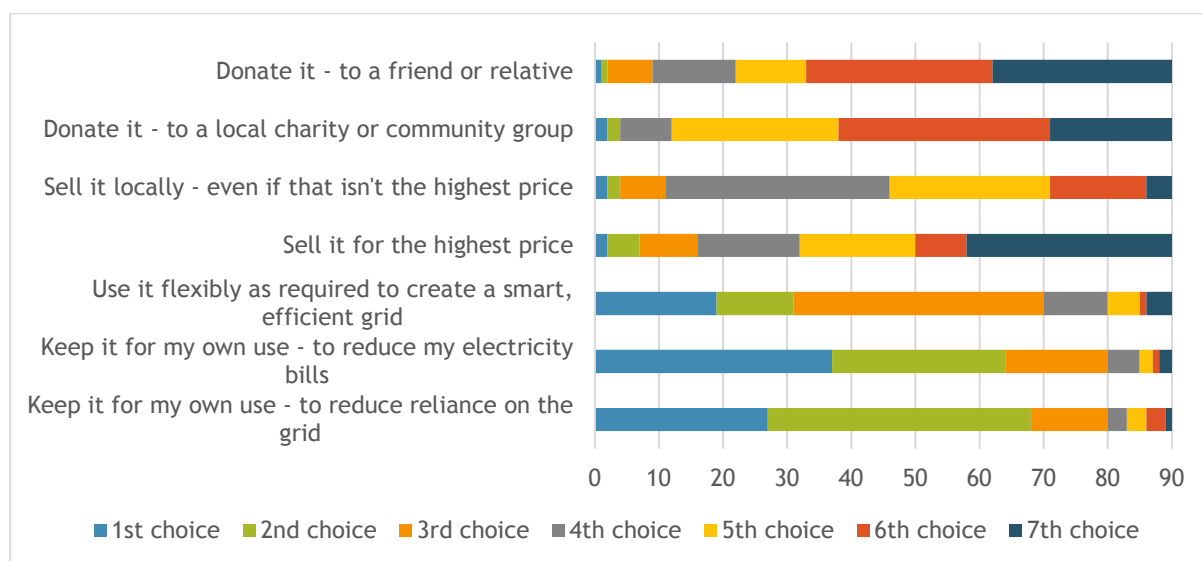
This issue was discussed earlier in [Objective 1 Q19 More communication and involvement wanted from \(or with\) the LEM team](#). Although only 1 respondent raised the point under this question (Q10) 18 householders (20%) made similar points within the comments sections of the online survey.

Q11 In the future, what would you like to do with the electricity stored in your home battery?

In Q11 the householders were asked to rank by preference what they would like to do with the electricity stored in their home battery. As there were 7 given factors, they therefore had to rank each factor from 1st choice to 7th choice. [Figure 7](#) below shows the full range of answers given by participants.

Although over 94% of respondents said that the concept of a smart flexible energy grid motivated them in Q10, when asked in Q11 what they would like to do stored electricity only 21% opted to 'use it flexibly to help create and manage a smart, efficient electricity grid' as their first choice, with 13% opting for this as their second choice. The majority preferred to keep the electricity for their own usage, either to reduce reliance on the grid, or to reduce their electricity bills.

Figure 7 What would you like to do with the electricity stored in your battery? (By number of survey respondents)



In the interviews this question was phrased differently as *"At the end of the LEM project would you be interested in trading your excess generation?"* As this was a more direct question it created a different set of results; which included more detailed analysis surrounding people's preferences.

34 of the 42 interviewees (81%) said that they **would** consider trading but there were several caveats within this; and as shown by the survey data trading wouldn't necessarily be their first choice. Of the 34 who would consider trading, 13 would consider trading because it fitted with the LEM concept of

creating a flexible grid which they thought would be environmentally beneficial; whether or not they actually made any profit from doing so. However, a further 11 of the 34 needed much more information first, particularly around whether it would actually be financially beneficial for them to trade rather than use the generation themselves within the home. Two of the 34 would consider trading but this was only as a second preference to being self-sufficient in the home; and only if there was additional capacity available above and beyond their own household needs; which was linked to the issue of battery capacities.

Of the 18 interviewees who saw battery capacity as a negative experience of the LEM project ([Objective 1](#)) 5 interviewees directly linked this to their perceived inability to trade as they didn't think they had enough excess generation:

"I'm not sure that with the size battery at the moment, that we have enough to export much anyway?"

"I'm handicapped because I've only got five kilowatts, so it goes back to my previous point. I'm a bit annoyed at that."

Of the 8 interviewees who didn't want to trade 4 stated that this was because they wanted to be self-sufficient. There was a strong opinion that self-sufficiency (being able to generate, store and use the generated electricity within the home) was the best option environmentally; with a feeling that earning money from the generation didn't fit with the household ethos of sustainability:

"As I say, the main thing for me was a degree of self-sufficiency rather than the financial side of it."

"That's not from a selfish point of view, that's from a sustainability..., if everybody was self-sufficient the planet would be looked after"

It became apparent from the interviews that householders had conflicting views around whether trading (in order to help create a flexible grid) or self-sufficiency within the household was the best option environmentally. Therefore, it would be beneficial for the householders to receive more advice on these two seemingly conflicting approaches. However, this should be impartial advice as many were sceptical of energy companies wanting to 'sell them a product' (particularly amongst the householders who preferred self-sufficiency).

Of the 4 remaining interviewees who didn't want to trade, one said that they would prefer to give it away rather than see an energy company profit from it:

"Not if it's going back via an energy supplier. I would give it to an elderly neighbour or to someone locally but I'm not going to be giving it back via an energy company where they can make profits on it."

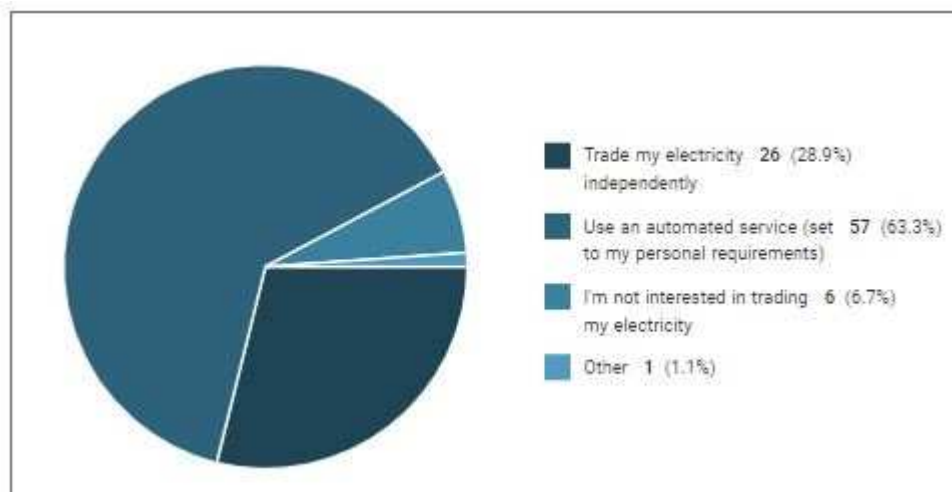
One interviewee didn't think that any payment earned through selling would be able to match the FiT payment that they already receive; and one interviewee stated that they would prefer any excess generation to be stored in a LEM-community storage facility to be drawn on by participants as needed; but that they would consider peer-to-peer trading with a neighbour as a second option. The final interviewee wanted more time to analyse and understand their own householder consumption data first before considering any future options.

Motivations for and against trading also refer to the 5 motivational attributes discussed previously in [Motivations for joining the LEM](#), and can be summarised as:

Motivation	To trade	Not to trade
Financial	to earn revenue to replace the Feed in Tariff	those who already receive high FiT payments - how will their FiT be impacted?; and those who don't want to sell at a low price and then have to purchase additional generation at a higher price (they need to see a financial benefit)
Environmental	to contribute towards a smart flexible energy system (potentially even if no financial benefit to self)	would rather have full autonomy in the home, so draw less from the grid
Community	would rather donate their excess generation (or sell it at a cheaper rate) to those in fuel poverty or to a community organisation; and peer-to-peer trading	
Innovation / Research	to prove the concept of trading to help establish a future LEM community	excess generation could be stored in a LEM-community battery to be drawn on as needed by participants
Technology	to find out how trading would work in practice	market not yet ready – so not worth it in the short term but a possibility once market established

Q12 Which trading route would you prefer?

In the online survey Q12 asked the householders whether they would prefer an automated trading route (set to their own household parameters) or whether they would prefer to trade independently. 63% opted for an automated trading route whilst 29% said that they'd prefer to trade independently and 7% expressed that they were not interested in trading at all.



Of those not interested in trading 83% stated that this was because they didn't know enough about trading to make a decision on it.

The only person who opted for 'Other' went on to state that they wanted to try peer-to-peer trading; but via a largely automated route:

"Peer-to-peer trading, not reliant on a single supplier, but using a different intermediary, virtual and largely automated, taking into account not only price but also CO₂ emissions."

Peer-to-peer trading is discussed in more detail in [Objective 3 What should a LEM provide?](#)

Reasons given for wanting an automated trading route included ease of use, better use of personal time, a more efficient process and less personal stress.

"I do not have the time to do this myself"

"Automatic so can set preferences and then not think about it"

"Market probably complex so would like it managed on my behalf"

"Don't want the stress"

The main reason given for wanting to trade independently was to have more control over the trading process, with the actual word 'control' mentioned by 14 respondents out of the 26 respondents who chose this option. Other themes included lack of trust in energy suppliers which was mentioned by 4 respondents and not wanting to increase the profits of large energy companies which was mentioned by 2 respondents:

"Retain of when/how much, potentially where it is sold to"

"We would prefer to have the control"

"More control over its use"

"Energy suppliers are greedy, genuinely wouldn't trust them to carry this out in a responsible/ethical way."

In the interviews this wasn't a direct question and as such was only directly answered by 9 interviewees; of which 8 said that they would prefer an automated route and one preferred to trade independently to start with, but then would be happy to move to an automated system once they understood the parameters.

Of those that preferred an automated route 4 stated that this was due to not having the time to do it themselves; 2 thought that it would be too much hassle; 1 thought that the LEM could optimise the whole system better if they had ultimate control and 1 didn't think that they would have the personal expertise to do it independently:

"I couldn't be bothered to cope with that. I might like looking at my app, but I don't want to have to work out whether I've got 5 kW to sell tonight, no, someone else would have to do it."

"I wouldn't have the time to manage it."

"I can't be bothered to fiddle with it. I want to be shown how to do it. So all of that's got to be made easy, I think, for people."

"Me and DIY and electrical things don't go together really! I'd prefer they set the parameters and then they just did what they wanted."

Analysis of Objective 2

Through the data received from both the online survey and the interviews we have assigned the following set of attributes to **householders** who are likely to engage in a local energy market:

- Financially motivated
- Environmentally motivated
- Community motivated
- Innovation / research motivated
- Technology motivated

As stated, these are not mutually exclusive factors, with people generally identifying with at least 2 of the motivations. In addition, as with the positive and negative experiences discussed in [Objective 1](#), some of these motivations are quantitative e.g. *"it was an understanding of the technology and its possibilities and revolving pound signs in front of my eyes"*; whereas other motivations are qualitative in nature e.g. *"And knowing that we are contributing to what hopefully is valuable research and what might come out of that. Gives me a warm glow."*

In particular the financial motivation was rarely the sole motivator; with almost all participants also seeing the LEM concept identify with their personal values, whether that be for the environment or for the community etc. Seventeen interviewees (40%) indicated that their primary motivation related either to their current career or a previous career. Those 17 interviewees span all 5 of the motivational categories above. Motivations also related to voluntary work undertaken in their local communities and other direct personal experiences such as higher education courses, family and social group influences and their political motivations.

As personal background was not an interview question this was only expressed where interviewees wished to do so to provide the interviewer with context for their motivations. Therefore, work experiences, education and social or political influences may have been factors for other interviewees which weren't recorded. This could be an area for further investigation in order to be able to identify characteristics.

Previous academic research shows that targeting both quantitative and qualitative motivations can be a beneficial way to promote pro-environmental behaviour and that targeting *multiple* motivations simultaneously will lead to an increased uptake (Steg *et al.*, 2014). However, as will be shown in [Objective 3 Incentives to Participation](#), if the LEM concept is to be implemented as a viable service option to other householders in Cornwall beyond the trial stage; the initial motivations towards innovation and technology become wholly or partially fulfilled. This is due to the LEM trial participants being the pioneers or 'innovators' of the LEM concept; proving the concept and trialling the technologies and the LEM platform. Conversely, at this stage the community motivation would increase if the LEM evolves into a viable local service provider (see [Objective 3](#)).

Beal, Rogers and Bohlen introduced the 'technology adoption lifecycle' in 1957 (Beal *et al.*; 1957), which is a sociological model that describes the adoption or acceptance of a new product, according to the demographic and psychological characteristics of 5 defined adopter groups. The model indicates that the first group of people to use a new product are the 'innovators', followed by 'early adopters' the 'early majority' and 'late majority', and finally the 'laggards'. This was later adapted by Rogers in 1962 as the 'Diffusion of Innovation theory'; which introduced the 'innovation bell curve' (Rogers, 1995)

(see [Figure 8](#)). Using Rogers' model, the LEM householders would be known as the innovators; those that trial and test a new service provision or product.

Figure 8 Rogers bell curve of innovation adoption



Source: Wikipedia, 2020

Rogers identifies the characteristics of the 'innovators' as:

"Innovators are excited by new technology. They have strong technical skills and want to get their hands on new technology as soon as it's available. They demand access to tech support and documentation. In exchange for getting access to new technology for little or no upfront cost, they expect to provide feedback that affects further development and refinement of the technology."

Innovators are also assumed to be older, well-educated and more prosperous. Whilst these definitions somewhat match the characteristics of the LEM participants (particularly those who identify as technology motivated) this is a somewhat blunt instrument; heavily concentrated on quantitative factors whereas in reality the qualitative motivations are also apparent; and equally, if not more, valued by the LEM participants.

However in examining motivations for joining the LEM in the future, beyond the 'innovators' stage; it would be prudent to assess the characteristics of the second group in the innovation adoption model, the 'early adopters' and combine these characteristics with what we have learnt from the LEM householders:

"Early adopters seek to adopt breakthrough technology to gain a competitive advantage. They are visionaries with the ability to connect new technology to a business goal. They willingly accept the risk of unproven innovations and are easily sold on new technology. In exchange, they expect their pilot projects to be well supported by vendors willing to make responsive adjustments to the technology."

Early adopters are assumed to be younger, well-educated and community focused (Rogers, 1995). The community motivations could therefore hold more importance to this group; which would link to the findings we have in [Objective 3](#) that the community incentive becomes more apparent in rolling out the LEM to a wider audience. However this group could also be more engaged in environmental issues as previous studies show a correlation between education level and pro-environmental behaviour (Poithou et al., 2016).

However, whilst the Diffusion of Innovation theory provides a useful lens for identifying traditional take-up rates of new products and services, and by whom; it may not provide enough urgency of the speed of change needed in the context of climate emergency and the need to rapidly decarbonise energy systems. Therefore, if a LEM is to assist the UK in achieving its net-zero aspirations by 2050 it will need to be accessible by a wide audience. This will mean for instance being accessible to those in different housing tenures; different income levels; and different motivational factors.

As stated earlier, research shows that targeting multiple motivations simultaneously will lead to increased uptake (Steg *et al.*, 2014). In addition, some academics stress the importance of social influences (e.g. peer power) in increasing uptake rates (Kastner and Bobeth, 2018). In [Objective 3 Overcoming Barriers](#) we discuss the need for clear communication in rolling out the LEM beyond the initial trial stage; however, the influence of the Cornwall LEM householders on their social networks should not be underestimated. Ten survey respondents and fifteen interviewees expressed how they have positively discussed their involvement with the LEM with friends, family, neighbours and colleagues, with one survey respondent adding:

"Word of mouth is more powerful than expensive marketing"

The survey and interview data however showed some anomalies in participants thinking towards the LEM concept which should be addressed if the LEM is to become a viable service proposition. The participants liked the general concept of the local energy market; although no-one had an exact definition of what the LEM was in practice (see [Objective 3](#)). It was apparent that the concept meant different things to different people; which appealed to their different motivational preferences. For instance, those that had research motivations had watched Centrica's animation of how a LEM could operate and were motivated by the concept of developing grid resilience; whilst those with community motivations were interested in how the LEM could help Cornwall as a place and the people within their local community.

However, although 94% of survey respondents were motivated by Centrica's animation which portrayed how a smart and flexible energy grid in Cornwall could operate in conjunction with a local energy market, this motivation didn't necessarily lead to participants seeing trading as an option for themselves. There was therefore a disconnection between the theory of a local energy market and the participants' role within shaping that. In particular there were differing views on whether energy self-sufficiency in the home was environmentally better (and better for the electricity network) than providing grid flexibility through trading. There therefore needs to be training given – possibly by independent advisors - as to which option is best. Also, it may have been beneficial for the researcher to have rephrased the word 'trading' as 'provide grid flexibility services' in order to overcome some of the connotation that trading was concerned with monetary value rather than establishing grid resilience.

Linked to this, further training is also needed on battery capacities. As shown in [Objective 1](#) battery capacity was a main cause of negative feedback from trial participants with 18 interviewees considering that their options for self-sufficiency and / or trading were hampered through not having sufficient battery capacity. Although not directly linked to participant characteristics it is important to show that participant take-up could be increased through further explanation of the LEM concept, core values and opportunities.

Objective 3: What might encourage people to participate? What needs to change to incentivise participation?

Overview

In the Householder online survey Objective 3 was explored through questions 13; 14 and 20. Q13 asked the respondents whether they would have joined the Cornwall LEM if they had to pay for the equipment themselves; whilst Q14 asked if they had to pay for the equipment what would most encourage them to do so?

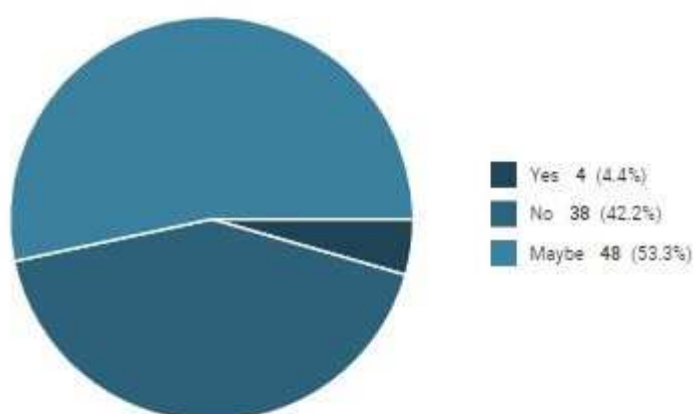
Question 20 asked 'What do you think would need to change to encourage other households to participate in a local energy market?'

In the interviews Objective 3 was explored through Q4 'What services do you think a LEM should provide for householders?'; Q5 'What might encourage other people to join a LEM?' and Q6 'If you could tell other people whether they should join or shouldn't join a LEM what would you say?'

Results

Q13 Would you have joined the Cornwall LEM if you had to pay for the equipment yourself?

The online survey gave three options of 'Yes', 'No' or 'Maybe'. Only 4.4% of survey respondents selected that 'yes' they would have joined the Cornwall LEM if they had to pay for the equipment themselves; with 42.2% stating 'no' and 53.3% stating 'maybe'. Due to survey anonymity it is not possible to tell if the 4.4% who stated 'yes' were households who already had solar PV installed and therefore would only have had to pay for the Sonnen battery to be installed, or whether these people would have had to have paid for the solar PV installation as well.



The responses given to Q13 appear to conflict with the responses to Q8 ([Objective 2](#)) where 17 respondents (19%) didn't think that free technology was either 'very important' or 'somewhat important' in their decision to join the LEM. There are several reasons why this may be. Firstly, we know that some householders were dissatisfied with the technology / installation that they received (as shown in [Objective 1, Q19](#)) and that they would have complained to the installer if they had been paying for the equipment / installation themselves. This includes those who would have preferred to have had a larger capacity battery installed had they been given the choice.

Secondly, the phrasing of Q8 may have been off-putting to some householders ('I wanted to have free renewable energy technology installed at my home'). This is because we also know from Q8, and from the corresponding interview data, that environmental motivations and financial motivations are particularly entwined, but that the financial motivation was rarely the main motivator to participate. Therefore, respondents may have seen this factor in Q8 as secondary to their other motivations to join the LEM.

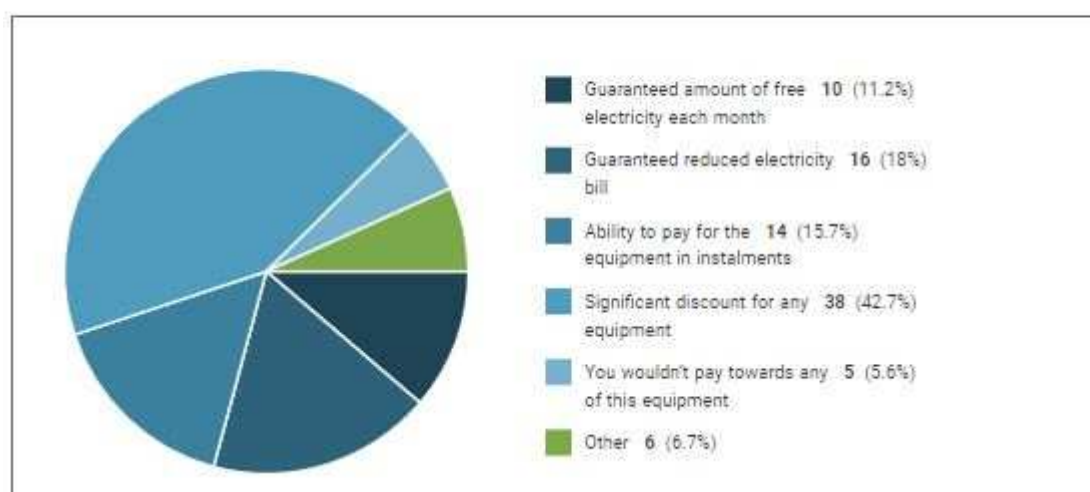
However, despite the differences in results between Q8 and Q13 it is still apparent that the free equipment was a major contributory factor for people to join the Cornwall LEM and this needs to be given strong consideration in any future LEM scheme.

Q14 If you had to pay for the equipment yourself what would most encourage you to do so?

Question 14 gave 5 options (of which respondents could only pick one answer); or they could select the 'Other' category and specify their answer.

43% selected the option of 'significant discount for any equipment'; followed by 18% who selected 'guaranteed reduced electricity bills' and 16% who selected 'ability to pay for the equipment in instalments'. 5.6% selected the option of 'wouldn't pay towards any of this equipment' and of the 6.7% who selected 'other' two people wrote that they would not have been able to afford the equipment / installation costs whilst the remaining comments related to payback times and requiring a clear cost / benefit analysis.

If you had to pay for the equipment yourself what would most encourage you to do so? (Please select one answer only)



Q20 What do you think would need to change to encourage other households to participate in a local energy market?

Question 20 was a free-text box for respondents to add their own comments; which 84 respondents completed. Responses were heavily weighted towards finance issues and the cost of installing the technology being a barrier to people (48 responses) and the withdrawal of the Feed-in-Tariff (FiT) (8 responses). Other responses included the need for energy advice (including independent advice);

greater awareness and marketing of the LEM concept and greater awareness of the environmental and / or community benefits of the LEM concept; as well as any financial benefits.

Three out of the six interview questions were devoted to answering Objective 3. This meant that interviewees were able to spend more time considering the issues and giving more detailed answers than they had through the online survey.

The responses to all 3 questions have been compiled under the following four headings: -

1. Incentives to participate
2. Barriers to participation
3. Overcoming barriers
4. Innovative approaches / what should a LEM provide?

1. Incentives to participate

- **LEM Concept**

The interviewees liked the general concept of the local energy market; although no-one had an exact definition of what the LEM was in practice.

"I'm not sure where a local energy market fits...Is it a provider of just the equipment? The actual utility? Is it help? You probably get a dozen different answers from different people."

It was also apparent that the concept meant different things to different people; which appealed to their different motivational preferences. Interviewees were thereby able to distinguish a range of motivational factors which could incentivise *other* people to join a LEM. These have been categorised using the 5 motivational factors identified in [Objective 2](#) for consistency; but as acknowledged earlier these should not be seen as mutually exclusive factors; with people generally identifying with at least 2 of the characteristics:

- **Environmental incentives**

Environmental incentives were the most frequently mentioned motivations; with 19 interviewees (45%) highlighting the benefits of the LEM concept as one solution to reducing fossil fuel usage and reducing individual carbon footprints.

It should be noted that immediately leading up to and during the interview timeframe climate change was high on the national media agenda; with reports on the Extinction Rebellion protests taking place in London; a David Attenborough documentary 'Climate Change – The Facts'; news of Greta Thunberg's transatlantic sail to New York to take part in a United Nations summit and continued #FridaysForFuture school strikes. These events were all commented on within the interviews, with several interviewees attending local Extinction Rebellion meetings and supporting school strikes. There was therefore a motivation to 'seize the initiative' and 'the time is now' for implementing environmental change. Comments included:

"Everyone should be putting as much money as they can afford into trying to mitigate this climate emergency. That would be my main reason, I think, for encouraging people."

"The planet's on its knees, you know? If this is one of the solutions that'll help, hell yeah, why aren't we?"

"Think of what Greta's been saying this week. We need all sorts of changes, this is a small part of what the whole world needs to do, and start realising that we can't go on burning fossil fuels. You know, that's the one that primarily impacts on the energy system. You know, the world is still pouring into coal fire power plants and there are much better alternatives."

"And I think there is a raised awareness throughout the whole community. The fact that this is an issue, David Attenborough says, so do what you can."

"From a local energy market point of view, if you're able to support yourself and people around you, it can only be a positive thing. You're also helping to reduce your carbon footprint and become more green which is making the grid more resilient, which seems to be a thing that's certainly crucial at the moment and it can only be a good thing."

- **Community incentives (including localness)**

The second most frequently mentioned incentive (43% of interviewees) was the community benefits that could be achieved through a LEM. Direct solutions to help the community are identified in Innovative approaches later; but purely from an incentive point of view interviewees expressed that local identity (especially Cornish identity) and helping the local community was a high motivator:

"Yeah, the environment, the community, a sense of community as well, like being a part of a co-operative, isn't it? You're all in it together, supporting each other and getting something out of it at the same time. Everybody loves that, don't they?"

"You could say to them, 'Look, it's not going to cost you very much, if anything. It's going to reduce your energy bills. It's going to save the planet with climate extinction and the icing on the absolute cake is, you're going to help the rest of the community by the social benefits. Here's the contract, sign here,' how could anyone refuse?"

"I think the strongest element that you've got to promote is the locality, the localness of it. Cornish people, in my experience, are fiercely patriotic. If it's going to do Cornwall good, that's good for them."

"Cornish sun producing Cornish electricity"

"The fact that it is local, that it's not having to go to Scotland and back again, or wherever it goes, I have not a clue. But the fact that it is produced here in Cornwall, and it stays in Cornwall, has got to be a good thing. You might even be able to sell that without a price differential. I mean, you know, if, 'Cornwall Energy' existed, I might buy my electricity from them instead."

"I think what works for the community works for most of the individuals as well. You get a lot more buy-in if you have something where the benefits are clear to everyone."

- **Financial incentives**

Thirteen interviewees (31%) saw financial incentives for others in joining a LEM, particularly for those that already had their own micro-generation as they saw that as the easiest way to enter a LEM without

having to finance home installations prior to joining; and also being able to instantly earn revenue through LEM trading:

"If people already have their own micro generation then it's also a good scheme for them to join."

"People would also be interested if they'd already got photovoltaics, wind power, batteries, if they're already kind of set up with all the kit ... to become a producer for that market."

It was also seen by 10 interviewees (24%) as a good opportunity for those who had capital to invest, stating that due to low interest rates people could receive a better return on their capital by installing microgeneration and trading through the LEM. These interviewees were generally the ones who had previously purchased their own solar PV prior to the LEM project; as they had seen their own financial benefits to PV ownership. (However, the reduction of the FiT was seen as a potential barrier to this as will be discussed in [Barriers to Participation](#) later.)

"When people aren't getting any interest off their savings and they just see their electricity bills going higher and higher. Just like me, they'll just think, it's an investment, isn't it, really?"

"I'm sure there'd be other people like us who would, if they could see the long term benefits, if you say, look, if you're going to buy a battery it's going to be £6 - 10,000 or whatever it is, but over five years you will save this amount of money and then you'll be quids in."

The potential reduction in energy bills was also seen as an incentive to participation. This was from the point of view of potential LEM participants who would install microgeneration and therefore have the ability to reduce their purchase of electricity from a supplier; as well as their potential to offset energy bills through exporting (trading) generation via the LEM.

In addition, interviewees also considered that energy bills could be reduced for those who wanted to join the LEM purely as buyers of generation (without being a microgenerator themselves). Although the interviewer clarified that there wouldn't necessarily be a cheaper tariff for those purchasing electricity from a LEM (as opposed to any other licensed supplier) due to inherent policy costs, several interviewees thought that price reductions could still be made through '*cutting out the middle man*' and '*electricity having less distance to travel*' i.e. staying within the local distribution network (see also [Overcoming barriers](#)).

- **Research and Technology incentives**

The remaining 2 motivations from Objective 2 were not seen as major incentives to induce others to join a LEM. Obviously, the original research motivation is removed; the motivation having been to join the trial to prove the LEM concept. Therefore, if the concept is indeed proven and rolled out to a wider audience that fulfils that original motivation. However, there is still an incentive towards trialling other forms of renewable energy technologies within the LEM and developing the concept further, with references towards making Cornwall a 'world leader' in energy solutions. This is discussed under [Innovative Approaches](#) later.

Likewise, with the technology motivation, whilst it is still somewhat apparent as an incentive for others to join a LEM this becomes more submerged within the environmental incentive and can be shown as an incentive to educate people on grid resilience.

2. Barriers to participation

Notwithstanding the incentives above, most interviewees could see potential barriers to participation in a LEM. The main barriers were seen as financial, but within this there are several factors as described below:

- Initial outlay costs of equipment and installation

The main barrier was seen as the initial cost of purchasing and installing microgeneration technology and home battery storage devices if these had to be paid for upfront without any subsidy or long-term preferential rate loan. Cost was identified as the main barrier to participation by 25 interviewees (60%) and 44 survey respondents (49%):

"It's price, isn't it; for everybody at the moment, it's price."

"Is this a solution just for the rich or isn't it?"

"It seems a shame in order to participate in hitting renewable targets you've got to be well off."

"Cost of technology. Yeah. I mean, we were unable to afford to put solar on the roof. We couldn't do it and I mean, this is true for large numbers of households"

- Closure of the Feed in Tariff

Related to the cost of equipment as above, some interviewees saw the closure of the Feed in Tariff (FiT) to new entrants as of April 2019 as a major deterrent to others investing in solar PV installations. When the FiT was first introduced in the UK in 2010 it provided a generous £0.47/kWh for households with small rooftop solar PV installations (Ofgem, 2018a). Although this gradually reduced year on year for newer installations, the FiT still provided a financial incentive with a clear payback period for domestic prosumers; with over 937,000 installations made by 2018 (Brown *et al.*, 2019).

Those interviewees who had previously invested in solar PV themselves had been able to see a clear payback period when they made their initial investment. They recognised that without this the price of solar PV installations became more problematical for potential future investors:

"Scrapping the FiT was typical short-term thinking by the government. FiT was brilliant and the government killed it. It's NUTS!! We need to press Ctrl / Alt/ Delete and start again."

"The government's reluctance to support the FiT going forwards, will negate households investing in renewable energy projects."

"There were various incentives, government schemes and that. I would have thought that they're going to have to reintroduce something like that. When people have got big mortgages and stuff like that, then the last thing they need is to be taking on something that's going to maybe take 15-20 years to pay itself back."

With the FiT ending there's no pay off and people won't get their money back. There's no incentive to buy PV & batteries.

- [Those in fuel poverty](#)

Continuing the theme of financial barriers was the theme of fuel poverty. The 2019 Annual Fuel Poverty Statistics show that over 13% of households across Cornwall are classed as being in fuel poverty; at almost 33,000 households (BEIS, 2019a). A household is considered to be fuel poor if it has higher than typical energy costs and would be left with a disposable income below the poverty line if it spent the required money to meet those costs.

One of the main problems associated with fuel poverty is that many households do not have the ability to make significant changes to the situation due to constraints such as being off the main gas grid; households with older people or disabled people who need additional heating requirements; a lack of insulation / energy efficiency; relationships between tenants and private landlords and the use of prepayment meters with higher tariffs (Groves *et al.*, 2019).

Interviewees were therefore concerned that the people who could most benefit from the LEM were the people who would least be able to access it:

"The ones who need it most are the ones who can least afford it."

"The renewable market, it's not cheap to get into and because people are not very well-off down here [Cornwall], they're the ones that need help most and they're the ones that are least able to afford to get the cheaper electricity. More often than not, they have the most inefficient heating systems in the houses as well."

"The people who can least afford to pay are probably paying the very most. If this could be used for some social good, then we'd be even more delighted. If everyone could pay the amount we're paying, even in fuel poverty, those who are on the universal credit, for example, could have an energy bill of 50-60p a day, that would be a huge result wouldn't it, for everybody, I would have thought."

This led to discussions around whether the LEM should be run for the benefit of the community as discussed in [Innovative Approaches](#) later.

- [Housing tenure](#)

As previously stated, all of the LEM householder trial participants were homeowners. Eight interviewees however expressed concern that those in rented accommodation (particularly privately rented accommodation) would not easily be able to access a LEM as a provider of microgeneration as the current LEM model relies on changes to the building fabric (whether or not this is provided for free by a third party such as Centrica).

"All this green technology is seen by tenants as playthings for the wealthy."

In the foreseeable future therefore, they considered that tenants would only be able to access a LEM through acting as purchasers of energy, rather than producers of energy without government intervention (which is discussed in [Overcoming Barriers](#) below).

- Trust issues

Eleven interviewees (26%) thought that trust would be a barrier to people engaging with a LEM. The theme of trust has also been discussed in Objective 2 in relation to peoples' attitudes towards trading. During the course of the interviews the BBC reported on a PV installer who had left customers financially worse off after being mis-sold loans against the price of their panels (BBC, 2019). This article was commented on by several interviewees and so the issue of trust was perhaps higher in interviewees' minds than may otherwise have been the case. The situation does highlight though how many customers feel that there is nowhere for them to go to receive independent advice on which solution is best for themselves. Comments included:

"You're always going to get people out there trying to sell something. They're going to claim this and claim that. But at the moment, I would be sceptical about anything anybody told me."

"People will be wary of power companies wanting to take advantage of them because of their profit motives."

"I'd avoid Centrica because they've got a bad name, so anything that mentions big energy companies is tarnished."

Other themes surrounding trust included trust in smart metering and renewable technologies; with the perception that people needed to be educated in the way that these technologies work:

"I think there's still a level of disbelief about whether these things are possible so people have got to really kind of understand that the technology is there, that it works, that they could participate in this."

"There's always sensitivity at the moment around the concept of 'Big Brother' and monitoring and things like that. I think there would be a lot of treading carefully around that."

- Reluctance to change existing behaviour

The final barrier was seen as peoples' reluctance to change their behaviour; especially in a culture where people have limited time and money to spend on becoming engaged in energy issues:

"It's very hard to get people behind a concept and signed up to it. There's so many people, apps etc. vying for their attention that to get their attention, it's quite difficult."

"People haven't got the knowledge or the willingness to change their behaviour."

"At the moment, you choose your energy supplier and then you forget about it until somebody tells you the prices have gone up and then people look around. You've got nothing to worry about, whereas the whole concept of buying and selling, there'd be a big proportion of the population would just go, life is complicated enough."

3. Overcoming barriers

Interviewees suggested a range of solutions for overcoming the perceived barriers to participation in order to enable the rollout of the LEM concept to a wider audience.

- *Government intervention / policy approach / Building Regulations*

The main solution for overcoming the participation barriers was a need for central government to make climate change solutions a serious priority - adopting policies to actively support decarbonisation of the energy system, making 'joined-up' decisions on how these policies would be enacted and financing this where appropriate:

"I mean, the government have gone completely the wrong way, by cutting all of the subsidies. So, you know, how can you sign up to say you are going to reduce your carbon footprint, on the one hand, and then on the other hand, cut your subsidies? I mean, it's no joined up thinking is there, whatsoever? Absolute, you know, policies made up on the hoof, basically. It's all electioneering in my opinion. Wild. Joined up thinking, basically, yeah. Actually, having a policy that makes sense, and that will deliver this carbon zero, and what have you, because it won't at the moment, that's for certain."

"Well, to be frank, the government talks out of the side of their mouth. So, they know what's going on in the world, they know that there's an energy crisis, it's been predicted that we don't have enough energy generation capacity in the UK with the rundown of nuclear power stations etc. So, they know all this, and they have various commitments, electric cars by a certain year, self-sufficient housing by a certain year etc. They're absolutely doing nothing.... So, they say they want to have zero carbon housing but don't do anything about it, not implement anything about it."

"You know, we are in a climate emergency they need to sort of step up, let's not bloody well start in 2030. Oh dear, when will the powers that be catch up? Well especially when ordinary people like us are moving faster than them."

Government intervention was mentioned by 26 interviewees (62%). As mentioned in the previous section, people saw the ending of the FiT as a retrograde move by the government if they are serious about decarbonisation. However, they sought wider solutions and enablement from the government to make domestic decarbonisation a reality. This included mandating renewable technologies into all new homes – whether individually through domestic solar PV, or through community scale developments in new estates; such as community ground source heat pumps or community electricity storage devices. Whilst many viewed this as the government's jurisdiction to mandate installation of technologies; 14 interviewees (33%) thought that it needed to be included in planning consents and Building Regulations:

"I mean at the moment new buildings were supposed to be zero carbon by 2016 and the Tory government decided that was too expensive for builders to do that. But, yes they should all be forced to be zero carbon and produce their own electricity and all have batteries, yeah, all new buildings."

"But the obvious thing is to bring out some law that says every new house built, solar panels and battery and air source heat pump."

"If they had them [new homes] built with all of the systems from now on, if the government said, "Right every single house from now on that's ever built in the UK has to have solar panels with a

battery." Which would encourage people, they wouldn't then have to join the local energy market, but it might encourage them to go, "Well, might as well."

"There's been a massive wasted opportunity with all of the additional building that's going on as well, because if the councils had mandated solar as part of the installations, it would have just gone in. Look how many homes have gone up, how much additional power generation we'd have had off the back of that?"

Six interviewees also mentioned that they would prefer for the government to put money into subsidising domestic renewable technologies rather than nuclear power:

"Divert a bit of money from nuclear."

"I'd much rather the money was spent on this than nuclear."

"I don't know how the economics stack up, but I imagine it would be cheaper than putting a new nuclear station in. So instead of nuclear costs you could have community battery storage sub stations at the end of the street."

- *Cost of equipment*

25 interviewees (60%) and 36 survey respondents (40%) discussed different ways that technology could be subsidised or made more affordable for people. These centred around two main options; the first being that there is some kind of subsidy element; and the second being that if these technologies were incorporated into all new builds (and potentially a government led retrofit programme), that the unit price would reduce enough to make them affordable:

"I think you've got two options. Either the manufacturers reduce the cost of the things or it has to be in some way subsidised. I don't think you can expect households to foot the initial setup bill, the setup costs. It's too great, as things stand."

- *Through subsidy or incentives*

"If it was free or subsidised or means tested in some way, that might be another way around it."

"Funding on this sort of scale has got to happen centrally. It's not going to be a devolved spend, it's got to be a central policy to spend money on this. I feel very lucky that we've managed to get ours for free and it would be nice to see opportunities to subsidise or to make this free for other people."

"If you address it as being an environmental issue that has neutral cost you will get some people involved because they feel strong enough about the environmental issues. I think if it costs money, you'll only get the hard-core people that want to do it. But if you incentivise it, you'll get a lot of people who want to do it, especially if the incentives look like they're sustainable long-term, rather than something that's going to be very short-term."

"It should be something, if you had a more community-based model, you could have a credit union type model that could do that."

"If there was a way of getting, perhaps some monthly payments that would almost save itself by the offset from the electricity, so it balances out, that's a potential, I guess. Just something that eases the impact - that makes it easier for people to prioritise it as well."

"The one that's going to be the winner has got to be essentially a financial incentive in my opinion. Even though more and more people are taking on board their responsibility to the environment, a lot of people don't feel they've got sufficient funds and sufficient money to be able to."

➤ *Through economies of scale*

"The economies of scale will then bring the prices down and this will then be better for everyone else."

"PV should be fitted in all new build homes which would reduce the price through economies of scale for all new builds. This should be part of the Building Regulations – you can then also do other things like aggregating and managing a complete estate if everything is installed straight away."

"But if solar was put into all new buildings it would help; and then it would also reduce the cost of the technology though bulk purchasing and installs. The more that are built the costs per unit will reduce and the technology gets better. In the end it becomes more cost effective."

➤ *Community scale installations*

As stated above some saw more viability in community scale installations rather than individual homes:

"If it can be a community thing, so it's actually within the estate. You have your own power plant. If it runs individually, people aren't always as efficient with it, whereas if you had a bigger system that runs the houses... it [could be] more cost effective installing one big system rather than 20-30 individual systems."

"I did think, does it make sense commercially to install, let's say 100 properties in St Ives or would it make more sense to stick a large crate battery in a field somewhere, with solar panels nearby. Would that work?"

"Maybe with a sort of substation-type approach, by putting in the larger battery storage, things like that. Like what Tesla did in Australia."

• *Education & Communication*

25 interviewees (60%) and 15 survey respondents (17%) discussed the need for education and communication of the environmental benefits of renewable technologies and the role that a LEM concept can play in enabling further rollout of domestic renewables. This included education at school about climate change in general, through to adult education and people talking to their neighbours about the positive aspects of domestic technologies, including relevant case studies:

➤ *Education*

"Education – our hope lies with children – look at the school strikes – the children will nag the older generations to get into it. The educated still don't get it. We need to get the message into schools – give kids the information and solutions when they're in primary school. By the time they're adults the technology costs will have come down and there will be a much wider range of technologies to install."

Kids are like sponges. Look at recycling uptake – kids nagged their parents – it's a good way in. If you educate the kids then you educate the parents too."

"Train the children and then they educate the parents by nagging."

"Most people think you need to get the men on board, but actually you need to include women. Women are generally the ones who are in the home using electricity during the day, so you need to get women on-board. And they then teach the children."

➤ *Communication / Case Studies*

"Information, people love figures. People like to know that X amount of that means one of that. So, you could say for the solar panels on your house, you're stopping 10 tonnes of coal being burnt every year. And figures like that, people are like, "What?""

"I think if you've got empirical data showing that they do work, it makes it much easier for other people to join."

"Hopefully, there's positive results from his study, this pilot study that shows it can be done. And scale it up after that."

"Social media - tell your friends, you know, have an initial set of people like us, and build it out. Keep, sort of, talking to your neighbours. I mean, we've already talked to the neighbours."

"It's making the general public aware of the potential of PV and batteries. There needs to be an educational advertising campaign."

"Communicate in a way that people can respond to positively. You can have the more complicated information for the people that want it but start simple and give local examples. Relate it back to people."

"Include community champions – community groups are a great way of reaching people – isolated people and the elderly and Sure Start centres for women."

• *Independent energy advice*

8 interviewees (19%) and 11 survey respondents (12%) mentioned the need for more energy advice; with several stating that this should be independent advice from a neutral third party such as Citizens Advice or Cornwall Council or through a local community group or forum.

"I think there's got to be something somewhere, an energy advisor. An independent advisor, so for people who are looking to buy an electric car or invest into renewables, they need to be able to go to someone who can offer them the truth."

"Again, you need a portal that you can point them at to say, "This is the place to go to for your advice." It's not there at the moment."

"There's a lot of noise going on out there, and then you think well, where do I look for the right information? But I think if you were part of a ...local forum where householders themselves could share hints and tips....it's actually how you use it and how you can save money and how people can share that information, advice and wisdom through local forums."

4. Innovative Approaches / what should a LEM provide?

As stated at the start of this Objective, no-one had an exact definition of what the LEM was in practice. Therefore, when asked what a LEM should provide there were many divergent answers.

"I'm not sure where a local energy market fits...Is it a provider of just the equipment? The actual utility? Is it help? You probably get a dozen different answers from different people."

"You've got to do a lot of thinking to work out what on earth the local energy market would be and then how would it work."

Responses have been grouped below into 3 different business model approaches to aid clarity; although there are obvious overlaps between what each model could potentially provide:

- LEM as a local energy company (using the LEM as a supplier)
- LEM as a community co-operative (run potentially by the community, for the community)
- LEM as a peer-to-peer trading market (using the LEM as an intermediary platform provider)

- LEM as a local energy company (LEC)

In this model the LEM would act as a supplier of electricity, offering a local tariff which links local generation with demand and providing local generators/customers with improved export and import prices.

"It seems a very good idea to have a local trade-in market. The more it can encourage people to use their stuff, when the electricity is cheaper and so forth, it all helps with the grid doesn't it and it helps the environment really. You're going to use more renewable energy that way, in the end."

Through this model people without microgeneration would still be able to participate in the LEM/LEC; purely by switching from their current electricity supplier to the LEM. Therefore, any electricity customer within Cornwall could take advantage of local price tariffs including those in rented accommodation and fuel poverty:

"It should be about providing security of supply and it should be about ensuring kind of optimum pricing of fuel, of electricity and ...it should also be looking at discounted fuel for fuel-poor households."

However, there were also suggestions around the LEM investing in community solar arrays for the benefit of customers:

"Imagine every house in Cornwall was linked to solar in some way, even if their own house couldn't have it, maybe some kind of solar array somewhere else that would be able to store it on a commercial basis. People could draw off it, I can't see any downsides to it really. Cornwall could be a world leader in it, couldn't it?"

Several interviewees also discussed the possibility of the LEM/LEC incorporating Time of Use tariffs (ToU). ToU is based on dynamic price signals derived from demand data from smart meters as well as generation data. During periods of high demand/low generation, prices would be higher and *vice versa* (Brown *et al.*, 2019).

"Future versions of smart meters will be able to cope with different charging regimes and ToU tariffs will come with more intelligent networks."

"Getting people to be smart about when they use electricity would seem like a very good idea. I'm sure there's lots of potential for people being encouraged to use electricity at different times than they do now."

"Even if you're just buying it in through the Local Energy Market, you might be saying, 'Okay, I'll switch it on now because I can get half price electricity,' say, why not? You can do the washing then or switch on the immersion heater or put on the dishwasher, stuff like that."

Other versions of the LEM/LEC included vehicle to grid (v2G) charging and ToU tariffs for electric vehicle (EV) charging:

"I think that the house battery is probably just an intermediate technology until electric cars could connect to the electricity grid... I mean we've got a battery of seven kilowatts and cars have batteries of 60 kilowatts...that's where the whole grid battery thing has got to explode and I'm not sure whether the house battery thing is even going to be a thing."

"I want to look into vehicle-to-home and vehicle-to-grid. I think that's the way to go – we're just at the beginning stages of that becoming a possibility and it would be wonderful to have everything connected."

"I could have it there [EV] half charged and then wait for the right electricity price to charge it up."

- *LEM as a community co-operative*

18 interviewees (43%) thought that there should be community benefits arising from a LEM. Whilst several of these interviewees spoke about the community benefits which could arise from the Centrica LEM project being rolled out to a wider audience, others thought that a LEM should be run by the local community, or at least for the benefit of the local community:

- *Run by the community...*

"It's an opportunity to source energy and provide energy – to give energy locally rather than through a big energy company. It's a no brainer. But it shouldn't be run by the Big 6 it should be done through a local co-op."

"A cooperative would be better so that money just gets ploughed back into it so that we see the benefits that can be spread out for other people rather than it just going into one person's pocket."

"It could be run as a co-op type scheme with people who know what they're doing. It should be a locally run, not-for-profit scheme with Government help to start it."

"Like a community project or something like that to benefit people, or perhaps say supplying cheaper or free electric to a school or something like that. So, that it could be something built back in that goes back into the community."

In this model the LEM would presumably need to be run as a LEC (as above) but the community could choose an alternative LEC provider, with some interviewees suggesting that Cornwall Council could be the provider. Reasons for wanting a different provider included both the not-for-profit angle and the trust angle as discussed in [Barriers to Participation](#) above.

➤ For the community...

"Energy equality...It should be about providing security of supply and it should be about ensuring kind of optimum pricing of fuel, of electricity and it should also be looking at discounted fuel for fuel-poor households."

"We can't store it all, can't keep it all, can't use it all. But if you've got a more mature person or someone that needs warmth during the day, if you could feed them at a really reduced rate because they sign up to something. They go through social services or pension credits."

"It should be used as a social welfare benefit. For instance, people in social housing or care homes would be able to purchase it cheaper than buying from the grid; also village halls, hospitals etc. It then becomes a community benefit."

"So many people could benefit; particularly the elderly who can't afford to heat their homes – a local scheme could help them."

No, you can't roll everything out free, but certainly if the money that was created by selling energy to people was then ploughed back into possibly supporting other people to have more solar panels, it's one of these self-supporting things

- LEM as a P2P trading market

Peer-to-Peer (P2P) energy trading can be defined as local energy trading between participants, where excess generation is traded amongst local individuals and organisations. Essentially, allowing households to become small energy providers (adapted from Murkin *et al.*, 2016) and (Long *et al.*, 2017).

Four interviewees stated that they liked the P2P trading concept; which included virtual trading between LEM participants; trading between local businesses and households; and trading to the wider Cornish community:

"It's about shared power between participants ... Look at industrial or commercial feasibility – householders can sell to industry during the day (when industry needs power) and industry sell to householders in the evenings (when there's no sun to fill the batteries)."

"Peer-to-peer, that mentality, to me that would make more sense. with Uber and things like that, it seems to be more where people are going, the same thing like if someone has a car, it's not really doing anything, so you might as well utilise it in that way. It's the same with electricity, if you're generating electricity and you're not using it someone else can make use of it."

A P2P market would allow anyone to be able to sell their excess generation or demand reduction to whomever they choose within their locality, including from domestic customer to domestic customer. P2P trading would appear to be one of the fundamental values of a LEM; offering the ability to trade electricity locally, within a defined area and between defined participants without the need for a third-party licensed supplier (TPLS). However, the current electricity trading regulations do not allow for this to happen due to several regulatory and market barriers (Bray, Woodman and Connor, 2018).

One major regulatory barrier to be overcome is that currently all transactions must be made through a licensed supplier and customers can only have one licensed supplier at any one time (Ofgem, 2017). It is therefore not a possibility for the householders to sell their excess generation *directly* to someone else.

On the reverse side, it is also not possible for a customer to buy electricity from anyone other than their sole contracted supplier.

However, local P2P trading could be beneficial to network management if all transactions occur within defined Grid Supply Points. This could help reduce network constraints, if trading occurred below the constraint area or bottleneck. This in turn could reduce the likelihood of curtailment for existing renewable generators and allow for additional network connections to be made for currently stalled projects.

➤ [sonnenCommunity?](#)

Due largely to the fact that householders were issued with Sonnen batteries; 5 interviewees (12%) stated that they had researched the 'sonnenCommunity' programme that is run in Germany and wondered whether this programme could be replicated in GB:

"I did see an article, I think it was on the Sonnen site, where they've got a whole town...and they're kind of providing electricity for the whole town, aren't they? I thought that's really interesting."

"The Sonnen kit that we've got, they do shared grid between users of it, but we're not set up in this country to do that... I don't know if that's something that is coming over here, you know down the line?"

With sonnenCommunity, participants must first own a solar PV system and purchase a Sonnen battery. Participants then pay a monthly membership fee of around €20 to belong to the group (this is instead of paying a monthly standing charge to an electricity supplier). The group is then run as a virtual power exchange between participants (akin to the P2P concept) which sees any excess generation deposited in a virtual energy pool which participants can then draw from on days when they don't have enough microgeneration to meet their household needs (*sonnenCommunity*, 2020). Thus, through balancing of demand and supply between members there is no need for a third-party electricity supplier.

It should be noted, however, that this model only financially benefits the members of the group, and so any financial benefits are not shared with the wider geographical community, which is what most interviewees wished to see when discussing community benefits. Therefore, if sonnenCommunity is a community, it is a community of interest rather than a community of place.

However, the LEM concept could be run as a community of interest, initially in the early days whilst the concept is tried and tested (in phases 1 & 2 of the Rogers bell curve of innovation adoption shown in [Objective 2](#)). There are however differences between the UK and German energy systems which make the concept more problematic in the UK. These include that the domestic electricity price per kWh in Germany is almost double what it is in the UK (Ovo Energy, 2020)³, whilst conversely, battery capital costs have fallen dramatically, thus making more financial viability for German householders to invest in the technology. Indeed 50% of Germany's residential PV array installations in 2018 were sold in conjunction with a battery (Clean Energy Wire, 2018). However, perhaps more importantly, the UK does

³ A comparison study of average national electricity prices undertaken shows that whilst the average UK domestic electricity price is currently the equivalent of 20 US cents per kWh, in Germany it is 35 US cents (Ovo Energy, 2020). This is mainly due to policy costs associated with Germany's clean energy transition which account for 53% of the electricity purchase price (Clean Energy Wire, 2020)

not as yet have the necessary market structure to enable such an arrangement as shown in the P2P section above.

Analysis of Objective 3

When asking the householders their views on what might encourage people to participate in a LEM; and what needs to change to incentivise participation, it became clear that no-one had a clear definition of what the Cornwall LEM actually was, or could become, beyond the scope of the 3-year trial. This in itself is a fundamental barrier to overcome if LEMs are to be developed and rolled out across GB.

45% of the LEM householder interviewees discussed the environmental incentives of a LEM; whilst 43% discussed wider community incentives. It should be recognised, however, that the Cornwall LEM concept was never portrayed by the project partners as a 'community' energy scheme; the 'local' in the LEM referring to the locality of the generation and its impact on the local distribution network; with wider social benefits only portrayed as environmental system benefits, not cheaper electricity for community projects.

In a recent paper, Devine-Wright comments on the inherent differences between 'local energy' and 'community energy' and examines how the terminology has shifted in recent years away from 'community' and towards 'local' (Devine-Wright, 2019). Devine-Wright summarises that community energy involves the 'bottom-up' participation of citizens in place-based, grass-root schemes; whilst local energy is characterised by the 'top-down' imposition of a standard model coordinated by market actors. He therefore concludes that there are two diametrically opposed ideologies at play in the two variants.

However, in the context of rapid decarbonisation to address Climate Change and to meet the target for net zero emissions by 2050 adopted by the UK government in June 2019 (Gov.UK, 2019) does the variant actually matter? Indeed, if the LEM is portrayed as a 'community of interest' which seeks electricity system benefits for the whole community, and not seen as a 'community of place' which seeks charitable benefits, does this help with the framing of the LEM concept?

A fundamental barrier therefore to address is the actual definition of what a LEM can provide. If it is not a community benefit scheme, then that should be made explicit to avoid future misunderstandings. Addressing this will then help to frame and give context to the other identified participatory incentives and barriers.

The ability to afford renewable technologies and battery storage devices was considered one of the major barriers to be overcome. This issue is much wider than whether the FiT should or shouldn't have been removed, as it was considered that many people would not be able to afford the equipment even with the FiT in place. The perceived solution to this problem was that Government should intervene in some way to make domestic technologies more affordable to a wider audience; whether that be through subsidies or grants. In addition, local authorities should mandate the inclusion of renewable and low carbon technologies in all new buildings local planning policies and Building Regulations; and should encourage retrofit programmes in existing buildings.

Several householders also thought that subsidies could be diverted from other programmes such as nuclear to help invest in domestic behind-the-meter technologies or community scale DER installations instead.

Previous consumer research shows that although there is widespread public support for energy transitions, how the substantial cost of this should be distributed across society still has many unanswered questions (Becker *et al.*, 2019). Conversely, research from Imperial College determines that reduced system operation costs of between 25% and 40% could be achieved through the deployment of new, cheaper, flexibility sources connected at the distribution level rather than from conventional generation on the transmission network. These benefits come from avoided or deferred network reinforcement costs, avoided generation build, avoided curtailment of low carbon generation, and better operation of the system (BEIS and Ofgem, 2017). Therefore, simplistically, the cost of the energy transition could be offset against the future savings to be made.

Education and communication were also seen as important elements in raising people's awareness; both of the environmental benefits of renewable technologies and the role that a LEM could play in reducing the carbon intensity of the electricity system and providing flexibility to overcome network constraints.

Communication was also seen as important in overcoming other barriers such as distrust and apathy. However, several interviewees wanted a place where they could signpost their friends and neighbours to receive independent energy advice.

Householder Survey Conclusions

The results of the Householder survey aimed to address the three research objectives:

- **Objective 1:** Evaluate householders' experience of the LEM so far.
- **Objective 2:** Identify characteristics that might define who is likely to or unlikely to engage in the provision of flexibility, energy or other services via a local energy market.
- **Objective 3:** What might encourage people to participate? What needs to change to incentivise participation?

Although these were 3 discrete questions which have been analysed separately in the body of this report, there was much overlap between them which we will summarise here.

Overall, the householders were thankful for their free equipment and for the opportunity to take part in the trial. They valued their contribution towards research and hoped that by being involved in the trial that they could help to prove that the LEM concept worked and could be rolled out to a wider audience. They also valued the opportunity to trial the equipment and to see what the personal impacts were to them as individual households by way of behaviour changes, reduction in bills and greater energy awareness.

The householders could see the environmental benefits of a LEM model in addressing grid flexibility needs and saw this as a solution to enabling more renewable generation to connect to the network. However, there were different opinions in how this could best be achieved. Was it environmentally better to be an energy island; by being more self-sufficient in the home and reducing personal reliance on the distribution network; or was it more advantageous to be flexible and to offer grid services as required to help alleviate network constraints? And if the latter, what were the mechanisms to ensure that this didn't make participants financially worse off due to the need to purchase additional electricity (at a potentially higher price per kWh) to offset generation dispatched to the network (at a potentially lower price per kWh)?

The majority of the householders therefore expressed a need for much more information about what future grid services might look like and what part they could play. Domestic grid services are however in their infancy at the moment and there are many new models which could be available to householders over the coming years. A LEM is only one of these models. It therefore seems necessary that there is an independent energy advice service made available to guide domestic customers through these different service propositions as they evolve and become viable. Householders were of the opinion that they would trust an organisation like Citizens Advice or their local Council to provide them with independent guidance; but that this service is currently lacking.

The householders were also of the opinion that there needed to be much more communication with the wider public on what the future energy system might look like in response to addressing climate change and realising the UK's net-zero ambitions by 2050. As this will have an impact on all domestic customers, within a short timescale, there is an urgent need for government to set the direction of what changes are necessary to the overhaul of the electricity system; how this will be effectively communicated to customers and what financial help there might be available to encourage behaviour change.

There are many actors involved in how the future system needs to adapt; from government, local authorities, the public, network operators, generators and suppliers; thus creating diffused responsibility for transition (Becker *et al.*, 2019)(whereas in a nationalised system all responsibility

could have been placed on the government to enact each component of system change). However, in a privatised system all of these actors are deemed responsible for their own element of system change and to contribute financially towards energy transition. Direction setting therefore needs to be made to coordinate change between all of these actors and individual responsibilities made clear, to ensure that all future change is made in a coherent fashion. This will also aid with the speed of transition if all actors are working towards a clearly defined outcome instead of trialling piecemeal alternatives.

A LEM therefore is one tool which could be used to enable the energy transition. However if the LEM concept is to be rolled out wider across the UK the starting point must be in defining the concept in a way that is easily understandable to the public and through shaping the parameters of what it can and can't achieve. Questions which must be answered include:

- What is a LEM?
- How does a LEM help reduce carbon emissions?
- How does a LEM help towards a smart, flexible energy system?
- Who does a LEM benefit?
- Does a LEM help my local community? If so in what ways?
- Will a LEM save me money? If so, how?
- Who should run a LEM?

However, it may not be the case that each LEM has identical characteristics. It may be possible for LEMs to differ depending on geographical location (e.g. urban / rural settings); different network requirements (e.g. in areas of network constraint) and different ownership types (e.g. whether run by the public sector / private sector). Lessons can be learnt for any future LEM on what worked well from this trial and what issues should be addressed early on to achieve greater engagement with domestic householders; particularly around communication.

We have identified the motivational characteristics of those who have engaged with the LEM to date and we feel that these should be built upon in initially rolling out the concept. However, if a LEM is to expand rapidly to achieve climate change goals it will need to be accessible by a much wider audience. This will mean being accessible to those in different housing tenures; different income levels; and different environmental perceptions and behaviours. This can only be achieved through government intervention and direction setting through policy.

Appendix 1 - Methodology

In 2019 the University of Exeter undertook a survey with all 100 LEM householders involved in the project. The Householder Survey included an online survey which was emailed to all participants, which was later followed up with individual interviews with 42 householders; of which 30 were conducted face-to-face and 12 were conducted by telephone. Although the questions were different between the online survey and the interviews; both were designed to evaluate householder responses to the three research objectives. In order to answer these objectives the survey and interview questions covered both a qualitative and a quantitative nature.

It was made clear on the survey form that respondents didn't have to answer all of the questions if they felt uncomfortable or didn't want to. This was reiterated on the Participant Information Sheet which accompanied the survey. All online survey and responses were anonymous and interview responses were confidential. The survey was compliant with GDPR regulations and was approved by the University's Research Ethics Committee.

The online survey was written using JISC online surveys, which is the approved software used by the University of Exeter. Both the survey data and the interview data were later entered into NVivo 12 and coded against the three research objectives. In accordance with the University's GDPR commitments, all response data is held in password protected folders on UoE servers. These folders are only accessible to research staff within the Energy Policy Group at UoE. The raw data will be held for a maximum of 5 years before being destroyed.

Online Survey

The University of Exeter sent the online survey to the 100 LEM householders in early 2019. The survey form was sent to householders in 2 tranches; the first commencing in February and the second tranche commencing in May 2019. The reason for surveying in two tranches was because we wanted the householders to have had their technology installed for a minimum of 3 months before completing the survey form so that they had experience of using the technology and the Sonnen App.

The first cohort of 31 householders were surveyed between 22/02/19 and 10/03/19. The link to the online survey was sent to the householders by way of email from the Householder team at Centrica's Cornwall LEM office on 22/02/19; with a reminder email sent on 04/03/19. We received a total of 30 completed surveys from the first cohort.

The second cohort of 69 householders were surveyed between 21/05/19 and 11/06/19. Again, the link to the online survey was sent to the householders by way of email from the Householder team at Centrica's Cornwall LEM office. The initial email was sent on 21/05/19. This time we had a slower response rate, so two email reminders were sent; the first on 28/05/19 and a final reminder on 04/06/19. We received a total of 60 completed surveys from the second cohort; totalling a 90% response rate from across all one hundred householders.

The online survey consisted of 21 main questions split into 3 separate sections (see [Appendix 3](#)). Nineteen of the questions were multiple choice questions which in some instances led on to follow-on questions relating to the answer given or had follow-on free text boxes for respondents to explain why a particular choice had been made. Question 20 was an open question asking for respondents' thoughts on what would need to change to encourage other households to participate in a LEM. There was then space left at the end of the survey (Q21) for any additional comments which respondents wished to make.

Interviews

In addition to the online survey, UoE undertook interviews with the householders relating to the 3 survey objectives. This enabled the interviewer to gain more insight into why the householders had joined the Cornwall LEM and their experiences and thoughts of being part of the project including their future expectations of what a LEM could provide. The interviews enabled the interviewees to discuss their views and experiences in more detail than had been possible through the completion of the online form, and to relay any other factors which they felt hadn't been covered in the survey. As the interviews were anonymous this also enabled the interviewees to raise any concerns without prejudicing their relationship with the Householder team at Centrica.

In August 2019 all 100 households were invited to contact the Researcher at the UoE if they wished to be included in the one-to-one interviews. This led to a response from 54 households, from which semi-structured interviews were held with 42 households; of which 30 interviews were conducted face-to-face and 12 were conducted by telephone call. Ten of the face-to-face interviews included three person interviews (interviewer plus 2 interviewees from the same household) whilst the remainder of the interviews were two person (interviewer and 1 interviewee).

The interview was designed to last approximately 45 minutes and consisted of 6 questions. Written consent was taken from all participants, including consent to audio record as appropriate. The majority of face-to-face interviews (28) were audio recorded with the recordings then transcribed and entered into NVivo 12. The interviewer made handwritten notes for the remaining 14 interviews which were then written up in full and entered into NVivo 12. All interviews were then coded using the NVivo 12 qualitative analysis software to determine key themes.

Data conflict & Bias

As the online survey was completed anonymously it wasn't possible to correlate individual survey responses with the corresponding interview data. Therefore the survey and interview data have been stored and analysed separately in NVivo 12 and all data used in this document has been reported as either survey data or interview data to exclude any instances of double counting.

There were several national news items broadcast either immediately prior to or during the interview period (late August to early October 2019) which were commented on by several interviewees which could have introduced either positive or negative bias into the interview process. These were:

- Extinction Rebellion protests taking place in London
- David Attenborough documentary 'Climate Change – The Facts'
- Greta Thunberg's transatlantic sail to New York to take part in a United Nations summit
- #FridaysForFuture school strikes for climate
- Power outages on 9th August – with National Grid's response published on 22nd September
- BBC reported that thousands had been mis-sold loans against solar PV
- Inauguration of a new Prime Minister and ongoing Brexit debates in Parliament

The first four news items were commented on in relationship to ongoing climate change awareness and personal responsibility in trying to reduce carbon emissions and fossil fuel reliance to mitigate climate change effects. The power outage on 9th August was commented on in relation to the need for future-

proofing the electricity grid which led to interviewees questioning whether a decentralised local electricity system could help to provide grid resilience. Finally, the last two items were used to show both distrust in energy 'salesmen' and the position of the UK government in effectively legislating to combat climate change effects. The prior leading to discussions on why there needed to be an independent energy advice portal; and the latter leading to discussions surrounding a need for more decisive environmental policy making.

Appendix 2 - Householder Demographic Profiles

The first section of the online survey was entitled '[You and Your Home](#)' and consisted of 9 multiple choice questions. Questions 1 to 4 were demographic profile questions to gauge the profile of the householders against the profile of Cornish residents as identified through the 2011 Census data figures for Cornwall (Cornwall Council, 2013).

Question 5 asked the respondents to rank the 10 most frequently mentioned national concerns as identified in the 'Public opinion in the European Union Autumn 2018 survey' (European Commission, 2018). This was to establish whether the respondents' main concerns correlated with the national concerns as identified for the UK.

Questions 6 and 7 related to prior ownership of renewable technologies and electric vehicles (EVs) and Question 9 asked how often participants switched their energy tariff. (Question 8 is included in [Objective 2.](#))

All of the residential trial participants had to be homeowners who were resident in Cornwall and aged 18 or over in order to qualify for participation. We matched the demographic profile of the survey respondents against the 2011 Census profiles for Cornwall (Cornwall Council, 2013) to determine whether (taking the pre-determined housing tenure and age restrictions into account); our survey results came from a demographic sample of Cornish residents.

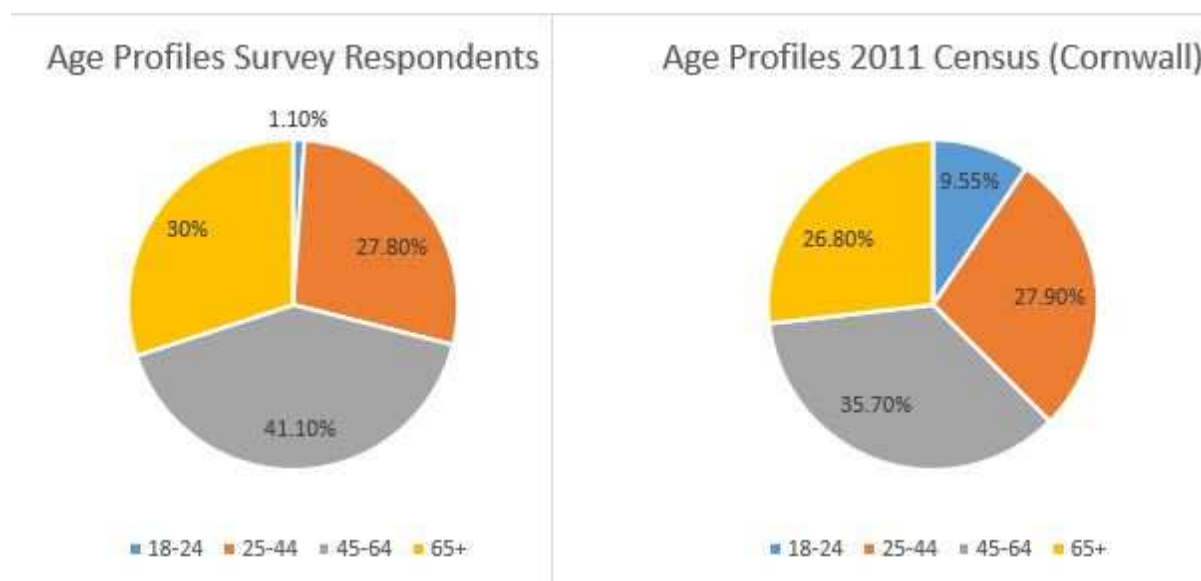
The 2011 Census profiles for Cornwall showed that 70% of the housing tenure was owner occupied with 29% residing in rented accommodation (17% private rented; 12% social rented). The 2011 Census also showed that 19% of the population were under the age of 18 (ONS, 2011).

We understood from the outset therefore that the trial excluded participants from 30% of the population based on their housing tenure; and 19% based on their age.

[Q1 Age](#)

We matched the age profiles of the survey respondents against the age profiles in the 2011 Census having first removed the 0-18-year olds to determine the percentage match against the remainder of the age profiles. This showed a low match in the 18-24-year-old age range; which is presumed to be due to the homeowner criteria, although this is not a correlation which is verifiable through the available Census data. However, the 25-44 age group was within 0.1% of being an identical match; whilst there were 5.4% more respondents in the 45-64 age group and 3.2% more respondents in the 65+ category.

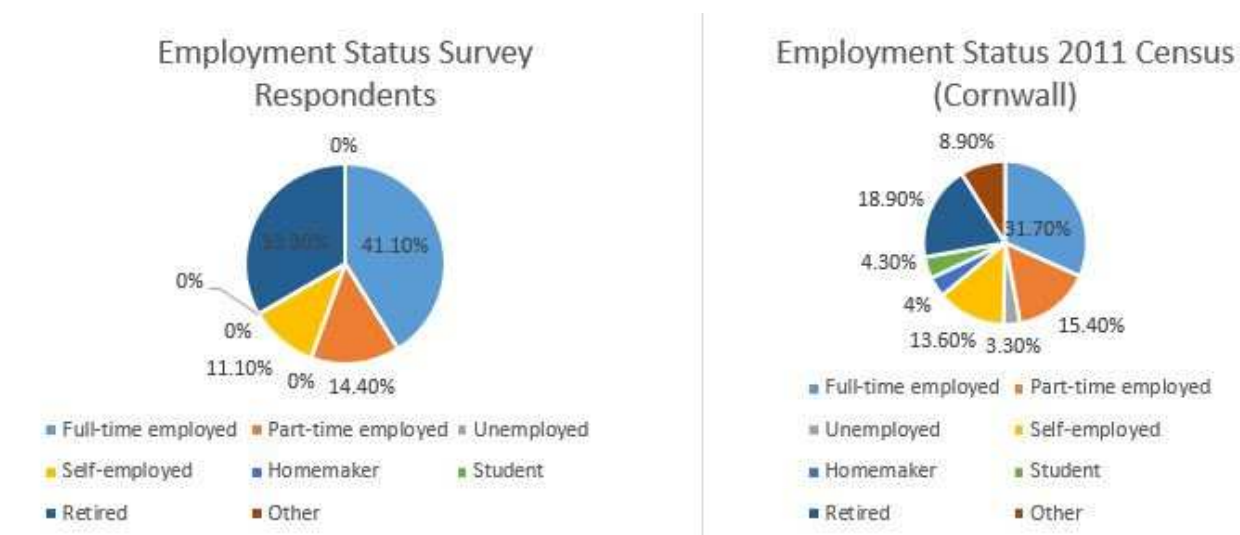
Figure 9 Age profiles



Q2 Employment Status

The survey respondents had almost 10% more full-time employed than the 2011 Census; 1% fewer part-time employed and 2.5% fewer self-employed. A third of the respondents (33.3%) identified as retired which is 14% higher than the Cornwall percentage. However, the Census employment figures are based on working age people of 16-74 making a direct comparison with the survey cohort unachievable. There were also no survey respondents who identified as unemployed, students, homemakers or 'other'.

Figure 10 Employment status

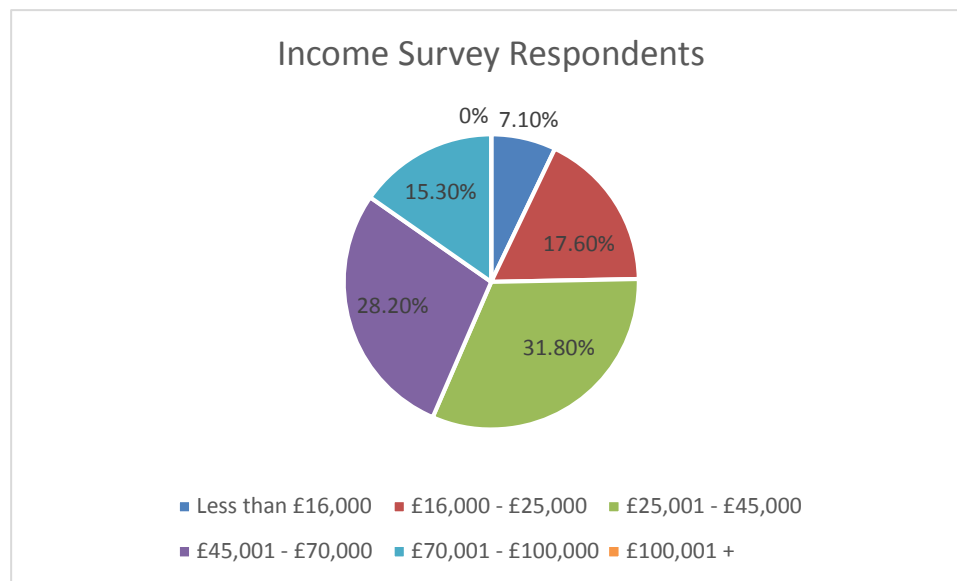


Q3 Income

The Office of National Statistics (ONS) excluded an income question on the 2011 Census so there is no Census data to match against the survey respondents. The ONS have however recently published average household income levels for the financial year ending 2019 which show that at the UK level mean income for the year was £35,300 with median income of £29,400 (ONS, 2019).

We asked the householders to provide their approximate household income per year (within set bands) to ensure that participants covered a range of income levels and therefore a range of householders. It was made clear that respondents didn't have to answer this question if they were uncomfortable doing so; despite all responses being anonymised. However, 85 respondents (out of the 90 who completed the survey) answered this question.

Figure 11 Income

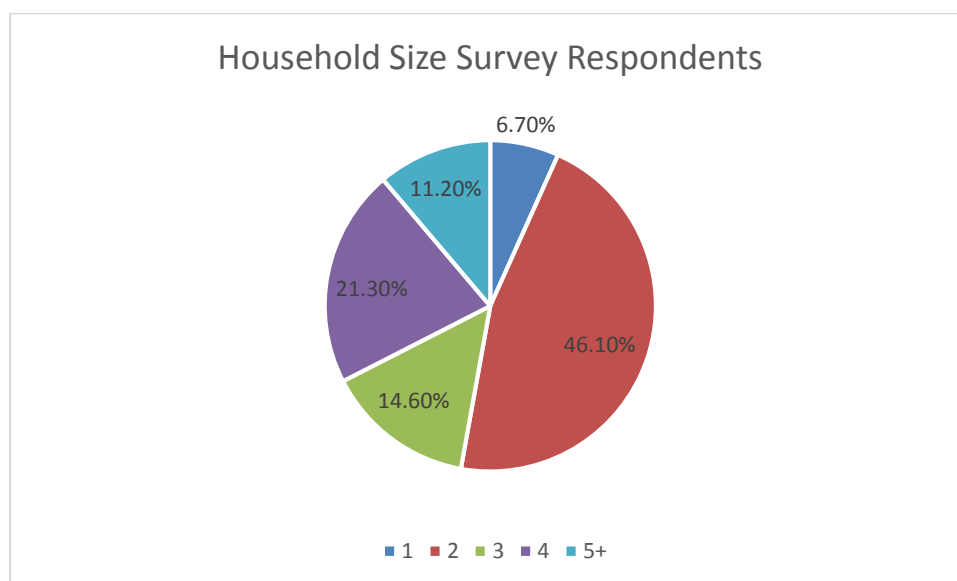


Due to the use of set income ranges for this question we are unable to produce an accurate mean or median income amount for the respondents. However, we can assess that almost a third fell within the national mean and median range; with almost 25% in the lower income bands and 43.5% in the higher income bands.

Q4 Household size

We know from the 2011 Census profiles for Cornwall that the average household size in Cornwall is 2.3 people per household. The survey respondents had slightly larger household sizes with an average of 2.8 people; although the largest majority (46%) were in 2 person households.

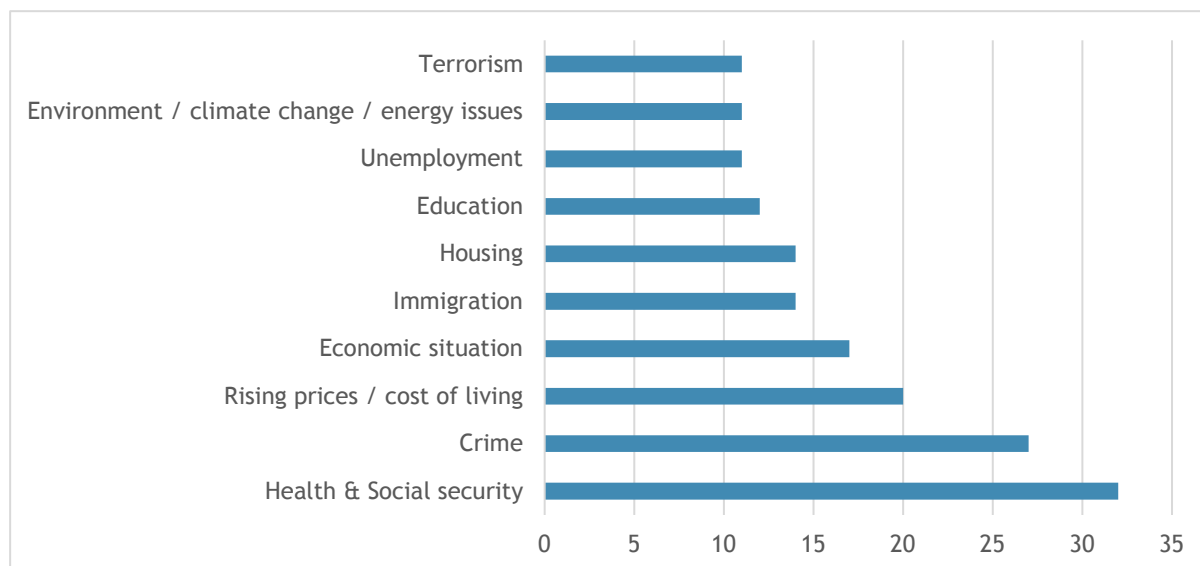
Figure 12 Household size



Q5 Ranking of National concerns

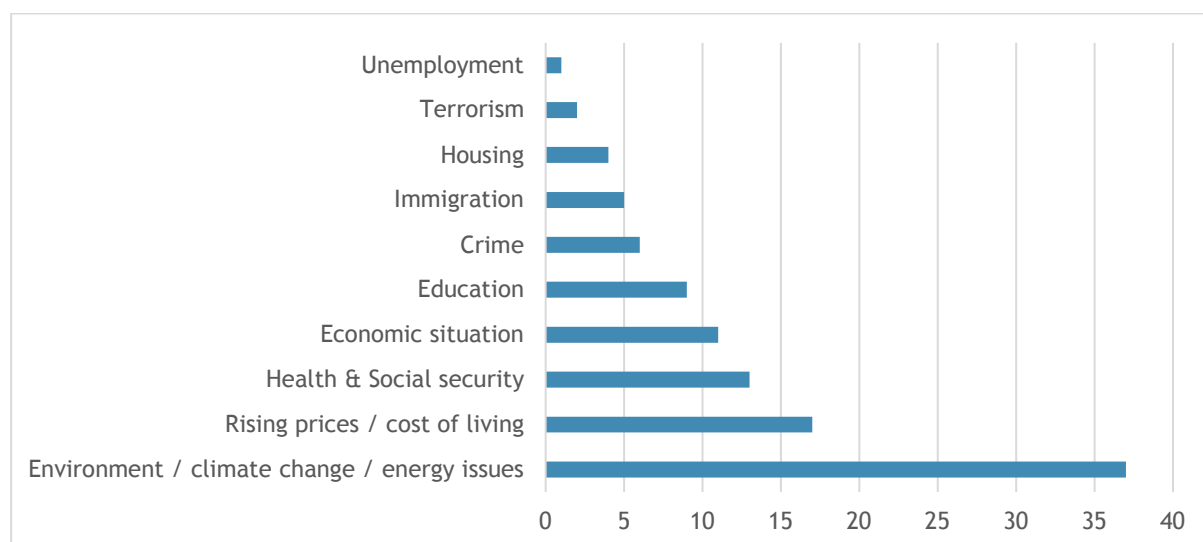
We asked the survey respondents' to rank 10 national concerns as identified by the EU survey of Public Opinion (European Commission, 2018). The EU survey showed that the 10 most frequently mentioned national concerns facing the UK as of November 2018 were those shown in [Figure 13](#). In the online survey we presented these 10 issues in alphabetical order (rather than rank order) and asked the respondents to rank them in order of priority for their own household. The LEM survey respondent results are shown in [Figure 14](#) for comparison.

Figure 13 UK Ranking of National Concerns, 2018



Source: European Commission (2018) *Standard Eurobarometer 90 – Autumn 2018 "Public opinion in the European Union, First results"*

Figure 14 Householder Ranking of Identified National Concerns



The respondents ranking contrasted most heavily in respect to the environment / climate change / energy category which was chosen as the highest priority concern by 37 survey respondents. This could show that the survey respondents are much more engaged in environmental concerns than the general public. However, there could also have been bias attributed to this question as the respondents knew that the online survey specifically related to energy issues. Therefore in an attempt to limit bias we placed this question within the demographic profile questions at the start of the survey; before respondents viewed the video clip in [Q10](#) of how the LEM could aid a 'smart, flexible energy system' and before we asked for their thoughts on the LEM project.

Other notable differences between the EU survey and the LEM survey respondents related to crime and housing which both scored lower than the national results. Unemployment was only the top priority for one respondent, which is suggestive of the fact that none of the survey respondents identified as being unemployed at the time of completing the survey.

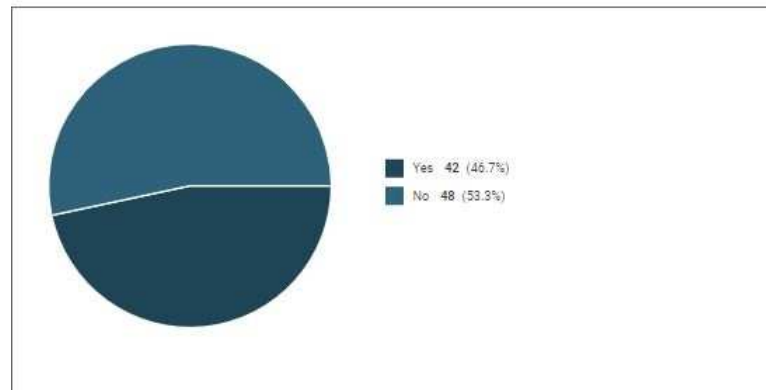
However, it is apparent that the householders' priorities and concerns differ significantly from the national concerns and therefore their responses to the survey should be viewed in the light of both pro-environmental behaviour as identified in the analysis of [Objective 1](#) and as 'innovators' as identified in the analysis of [Objective 2](#).

Q6 Did you have any renewable energy technologies at your home before you joined the Cornwall LEM project? And Q7 Do you own / lease any EVs or are you thinking of getting any?

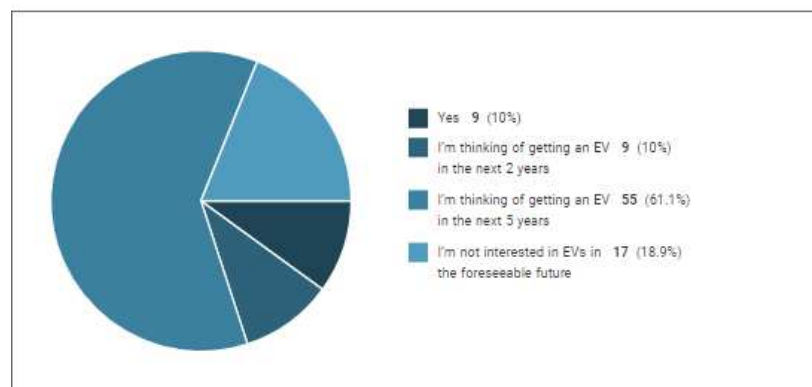
Almost 47% of survey respondents already had some source of renewable technology prior to participation with the LEM project. (This very closely matches the actual percentage of 46% who had solar PV installed prior to the project start.) This also points to the fact that almost half of the LEM householders were from a sector of society who were already engaged in energy issues prior to their involvement in the LEM.

In addition, 10% of survey respondents owned or leased an electric vehicle (EV); with only 17% of respondents not interested in converting to an EV within the next 5 years.

Did you already have any renewable energy technologies at your home before you joined the Cornwall LEM project?



Do you own / lease any electric vehicles (EVs) or are you thinking of getting any?



Q9 How often do you switch your energy tariff?

29% of survey respondents claim to switch their energy tariff every 12 months; whilst a further 44% claim to switch occasionally (approximately every 18 months to 3 years). Only one respondent claimed to never switch their tariff. These switching rates are higher than the UK average which again point to the respondents being much more engaged in energy issues than the general public.

Although national annual switching rates have increased during the last 4 consecutive years, annual switching rates for electricity had only reached 18.4% as of June 2018 (Ofgem, 2018b). This is more than 10% lower than the online survey response.

Appendix 3 – Survey and Interview Questions

Survey Questions

Section 1 - About You and Your Home

Q1 Please select your age range

Q 2 What is your current employment status?

Q 3 What is your approximate household income per year?

Q 4 How many people live in your home?

Q 5 Top 10 National Concerns

Q6 Did you already have any renewable energy technologies at your home before you joined the Cornwall LEM project?

Q7 Do you own / lease any electric vehicles (EVs) or are you thinking of getting any?

Q8 Please indicate how important each factor was in your original decision to get involved in the Cornwall LEM project.

Q9 How often do you switch your energy tariff?

Section 2 Future Expectations

Q10 Through your involvement with the Cornwall LEM you are helping us to understand how a smart, flexible electricity grid could operate in the future which could be of great benefit to society (as shown in the video clip). Does this particular concept motivate you?

Q 11 In the future what would you like to do with the electricity stored in your home battery?

Q 12 In the future would you prefer to trade independently or through an automated route?

Section 3 Your thoughts on the Cornwall LEM project

Q13 As part of the Cornwall LEM project you have had free technology installed at your property which is yours to keep. However, would you have joined the Cornwall LEM if you had to pay for the equipment yourself?

Q14 If you had to pay for the equipment yourself what would most encourage you to do so?

Q15 Do you use the battery app to check how your equipment is performing?

Q16 As a result of the equipment being installed do you feel that you are more aware of the energy you use and generate in your home?

Q17 Has the way in which you use electricity changed since your involvement with the Cornwall LEM project?

Q18 What positive impacts has involvement with the Cornwall LEM project had on your household?

Q19 What negative impacts has involvement with the Cornwall LEM project had on your household?

Q 20 What do you think would need to change to encourage other households to participate in a local energy market?

Q21 If you have any additional comments you'd like to make about the Cornwall LEM project please feel free to add them here.

Interview Questions

Q1 What was your main reason for wanting to be involved in the Cornwall LEM project?

Q2 Describe any positive or negative experiences of being involved with the Cornwall LEM project

Q3 At the end of the LEM project would you be interested in trading your excess generation?

Q4 What services do you think a LEM should provide for householders?

Q5 What might encourage other people to join a LEM?

Q6 If you could tell other people whether they should join or not join a LEM what would you say?

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Acronyms

BEIS – Department for Business, Energy and Industrial Strategy

BTM – behind-the-meter

DE – distributed energy

DER – distributed energy resources

DNO – distribution network operator

ESO – electricity system operator (National Grid)

FiT – Feed in Tariff

kWh – kilowatt-hour

LEC – local energy company

LEM – local energy market

Ofgem - Office of Gas and Electricity Markets

P2P – peer to peer (trading)

UoE – University of Exeter

WPD – Western Power Distribution (the DNO which covers Cornwall)